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ACOP

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1. SCOPE AND INTRODUCTION

This document defines and details the AMS-02 Crew Operation Post (ACOP) design.

This report, issued for the program CDR, gives a general functional description and specification of ACOP. Design information, including avionics design, software design, mechanical design and system block diagrams, is also provided.

This document includes a detailed description of the mechanical design. For avionics design and software design a general description is given: for details see the Electrical Analysis and Design Report (ACP-RP-CGS-004 Is2) and the Software Architectural Design Document (ACP-TN-CGS-003 Is1).

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD	Doc. Number	Issue / Date	Rev.	Title / Applicability
1	SSP 52000-IDD-ERP	D / 6.08.03		EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
2	NSTS/ISS 13830	C / 01.12.1996		Implementation Procedures for Payloads System Safety Requirements – For Payloads Using the STS & ISS.
3	JSC 26493	17.02.1995		Guidelines for the preparation of payload flight safety data packages and hazard reports.
4	SSP 50004	April 1994		Ground Support Equipment Design requirements
5	SSP-52000-PDS	March 1999	B	Payload Data Set Blank Book
6	SSP 57066	October 28, 2003		Standard Payload Integration Agreement for EXPRESS/WORF Rack Payloads
7	GD-PL-CGS-001	3 / 17.03.99		Product Assurance & Rams Plan
8	SSP 52000 PAH ERP	November 1997		Payload Accommodation Handbook for EXPRESS Rack
9	SSP 50184	D / February 1996		Physical Media, Physical Signaling & link-level Protocol Specification for ensuring Interoperability of High Rate Data Link Stations on the International Space Program
10	SSP 52050	D / 08.06.01		S/W Interface Control Document for ISPR ***ONLY FOR HRDL, SECTION 3.4 ***
11	ECSS-E-40	A / April 1999	13	Software Engineering Standard
12	AMS02-CAT-ICD-R04	29.08.2003	04	AMS02 Command and Telemetry Interface Control document. Section AMS-ACOP Interfaces
13	SSP 52000-PVP-ERP	Sept. 18, 2002	D	Generic Payload Verification Plan EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads
14	NSTS 1700.7B	Rev. B Change Packet 8 / 22.08.00		Safety Policy and Requirements for Payloads using the STS
15	NSTS 1700.7B Addendum	Rev. B Change Packet 1 / 01.09.00		Safety Policy and Requirements for Payloads using the International Space Station
16	SSP 52005	Dec. 10, 1998		Payload Flight equipment requirements and guidelines for safety critical structures
17	NSTS 18798B	Change Packet 7 10.00		Interpretation of NSTS Payload Safety Requirements
18	MSFC-HDBK-527	15.11.86	E	Materials selection list for space hardware systems Materials selection list data
19	GD-PL-CGS-002	1 / 12.02.99		CADM Plan
20	GD-PL-CGS-004	2 / 07.04.03		SW Product Assurance Plan
21	GD-PL-CGS-005	2 / 09.05.03		SW CADM Plan

Table 2-1 Applicable Documents

2.2 REFERENCE DOCUMENTS

RD	Doc. Number	Issue / Date	Rev.	Title
1	GPQ-MAN-02	1		Commercial, Aviation and Military (CAM) Equipment Evaluation Guidelines for ISS Payloads Use
2	BSSC (96)2	1 / May 96		Guide to applying the ESA software engineering standards to small software projects
3	GPQ-MAN-01	2 / December 98		Documentation Standard for ESA Microgravity Projects
4	MS-ESA-RQ-108	1 / 28 Sept. 2000		Documentation Requirements For Small And Medium Sized MSM Projects
5	PSS-05			Software Engineering Standards
6	GPQ-010	1 / May 95	A	Product Assurance Requirements for ESA Microgravity Payload. Including CN 01.
7	GPQ-010-PSA-101	1		Safety and Material Requirements for ESA Microgravity Payloads
8	GPQ-010-PSA-102	1		Reliability and Maintainability for ESA Microgravity Facilities (ISSA). Including CN 01
9	SSP 52000-IDD-ERP	E / 09/09/03		EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
10	ACD-Requirements-Rev-BL	September 2005	Base Line	ACOP Common Design Requirements Document
11	ECSS-Q-60-11A	1 / 7 Sept. 2004		De-rating and End-of-life Parameter Drifts – EEE Components

Table 2-2 Reference Documents

3. DEFINITIONS AND ACRONYMS

A

AAA	Avionics Air Assembly
ABCL	As-Built Configuration data List
ACOP	AMS-02 Crew Operation Post
ACOP-SW	ACOP Flight Software
ADP	Acceptance Data Package
AMS-02	Alpha Magnetic Spectrometer 02
APS	Automatic Payload Switch
AR	Acceptance Review
ASI	Agenzia Spaziale Italiana *(Italian Space Agency)*
ATP	Authorization To Proceed

B

BC	Bus Coupler
BDC	Baseline Data Collection
BDCM	Baseline Data Collection Model

C

CAD	Computer Aided Design
CCB	Configuration Control Board
CCSDS	Consultative Committee on Space Data Standards (standard format for data transmission)
C&DH	Command & Data Handling
CDR	Critical Design Review
CGS	Carlo Gavazzi Space
CI	Configuration Item
CIDL	Configuration Item data List
CM	Configuration Management
COTS	Commercial Off The Shelf
cPCI	CompactPCI (Euro Card sized standard interface to the PCI)
CSCI	Computer Software Configuration Item
CSIST	Chung Shan Institute of Science and Technology

D

DCL	Declared Components List
DIL	Deliverable Items List
DIO	Digital Input / Output
DML	Declared Materials List
DMPL	Declared Mechanical Parts List
DPL	Declared Processes List
DRB	Delivery Review Board
DRD	Document Requirements Description

E

EEE	Electrical, Electronic & Electromechanical
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
ER	EXPRESS Rack
ERL	EXPRESS Rack Laptop
ERLC	EXPRESS Rack Laptop Computer
ERLS	EXPRESS Rack Laptop Software
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
EXPRESS	EXpedite the PRocessing of Experiments to Space Station

F

FEM	Finite Element Model
FFMAR	Final Flight Model Acceptance Review
FLASH	Rewriteable persistent computer memory
FM	Flight Model
FMECA	Failure Modes, Effects & Criticalities Analysis
FPGA	Field Programmable Gate Array
FSM	Flight Spare Model

G	
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
H	
HCOR	HRDL Communications Outage Recorder
HD	Hard Drive
HDD	Hard Disk Drive
HRDL	High Rate Data Link
HRFM	High Rate Frame Multiplexer
HW	Hardware
I	
ICD	Interface Control Document
I/F	Interface
IRD	Interface Requirements Document
ISPR	International Space-station Payload Rack
ISS	International Space Station
J	
JSC	Johnson Space Center
K	
KIP	Key Inspection Point
KSC	Kennedy Space Center
KU-Band	High rate space to ground radio link
L	
LAN	Local Area Network
LCD	Liquid Crystal Display
LFM	Low Fidelity Model
LRDL	Low Rate Data Link
M	
MDL	Mid-Deck Locker
MGSE	Mechanical Ground Support Equipment
MIP	Mandatory Inspection Point
MMI	Man Machine Interface
MPLM	Multi-Purpose Logistic Module
MRDL	Medium Rate Data Link
N	
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NCR	Non Conformance Report
NDI	Non Destructive Inspection
NRB	Non-conformance Review Board
NSTS	National Space Transportation System (Shuttle)
O	
OLED	Organic Light-Emitting Diode
ORU	Orbital Replacement Unit
P	
PA	Product Assurance
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect (personal computer bus)
PCS	Personal Computer System
PDR	Preliminary Design Review
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PFMAR	Preliminary Flight Model Acceptance Review
PLMDM	Payload Multiplexer De-Multiplexer

PMC	PCI (Peripheral Component Interconnect) Mezzanine Card
PMP	Parts, Materials & Processes
PROM	Programmable Read Only Memory
PS	Power Supply
Q	
QM	Qualification Model
R	
RFA	Request For Approval
RFD	Request For Deviation
RFW	Request For Waiver
RIC	Rack Interface Controller
ROD	Review Of Design
ROM	Read Only Memory
RX	Reception
S	
SATA	Serial Advanced Transfer Architecture (disk interface)
S-Band	Space to ground radio link
SBC	Single Board Computer
SC MDM	Station Control Multiplexer De-Multiplexer
ScS	Suitcase Simulator
SDD	Solid-state Disk Drive
SIM	Similarity Assessment
SIO	Serial Input Output
SOW	Statement Of Work
SPF	Single Point Failure
SRD	Software Requirements Document
STS	Space Transportation System (Shuttle)
SW	Software
T	
TBC	To Be Confirmed
TBD	To Be Defined
TBDCM	Training & Baseline Data Collection Model
TBDCMAR	TBDCM Acceptance Review
TBP	To Be Provided
TCP/IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
TM	Telemetry
TRB	Test Review Board
TRR	Test Readiness Review
TRM	Training Model
TX	Transmission
U	
UIP	Utility Interface Panel
UMA	Universal Mating Assembly
USB	Universal Serial Bus
#	
100bt	Ethernet 100Mbit Specification
1553	Reliable serial communications bus

4. DESCRIPTION OF ACOP

The ACOP System is a reliable special purpose computer intended to fly on the International Space Station (ISS) as a payload installed into an EXPRESS ISPR in the NASA US laboratory module. The main objective of ACOP is to provide an ISS Internal Facility capable of supporting AMS-02 experiment, performing the recording of Science data.

In particular, ACOP shall allow a more flexible and efficient use of ISS telemetry downlink, providing a backup of data generated by AMS-02 and preventing, in this way, possible losses of valuable data. In addition, ACOP provides a control and monitoring interface for the on-board crew to the external AMS payload. It also permits large software uploads into AMS.

ACOP is not designed to provide safety critical commands to AMS-02.

ACOP system shall be installed in the U.S. Laboratory Module, on the ISS, in one EXPRESS rack (see, for reference, Figure 4-1).

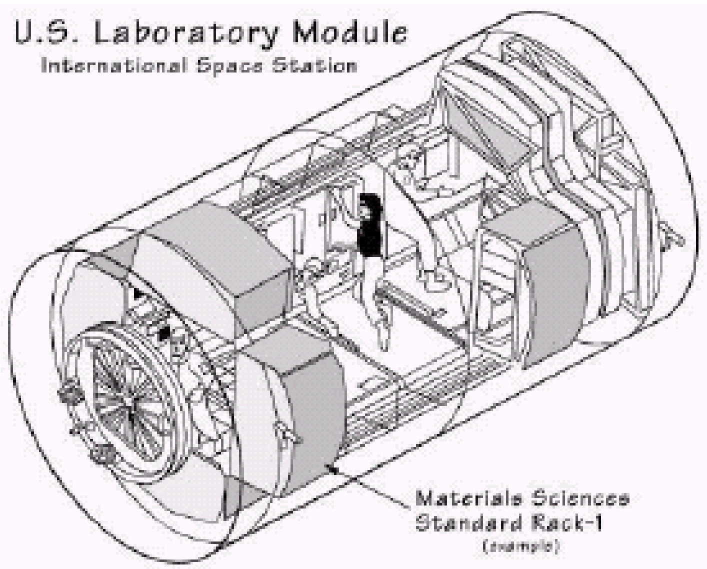

Figure 4-1 US-LAB

The standard configuration of an EXPRESS Rack is commonly known as 8/2. This means the rack can accommodate eight ISS Locker / Middeck Locker (MDL) units and two International Subrack Interface Standard (ISIS) units, as shown in Figure 4-2 and Figure 4-3. Figure 4-4 shows ACOP installed in such a rack (the location within the rack is just an example, the actual location will be determined by the ISS program).

On-board spare parts, including hard drives shall be accommodated in a standard soft bag.

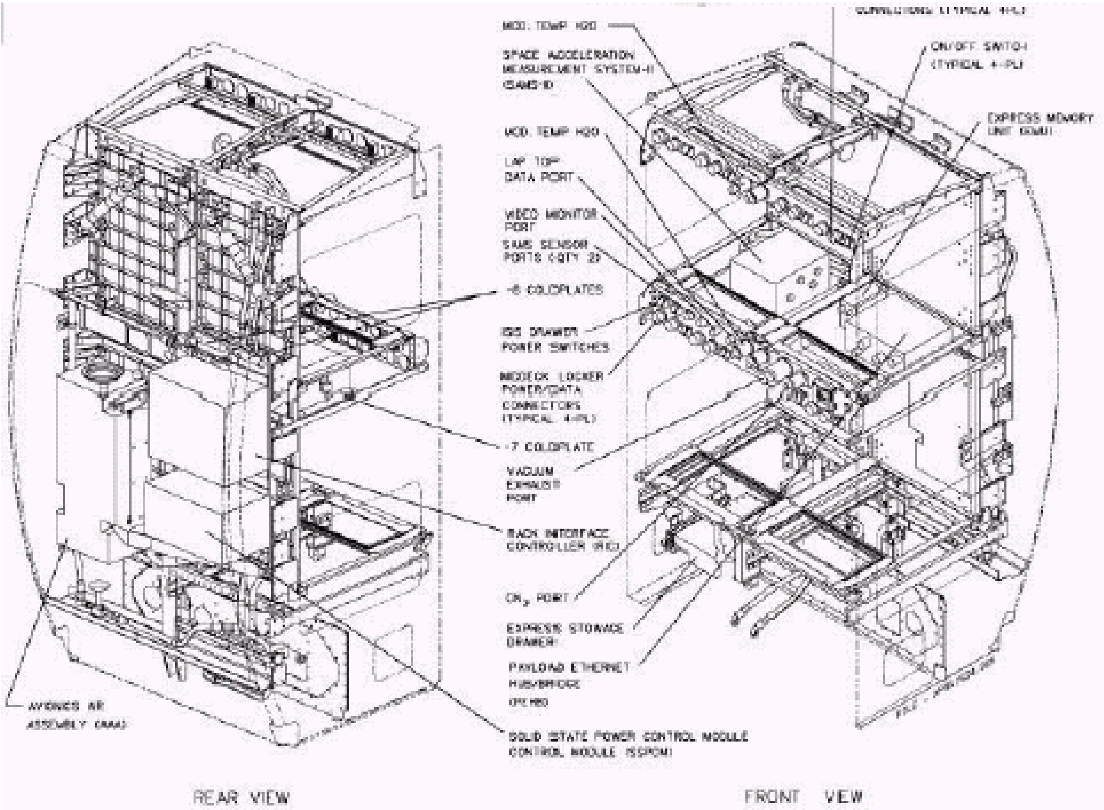

Figure 4-2 Example of an EXPRESS Rack (3D view)

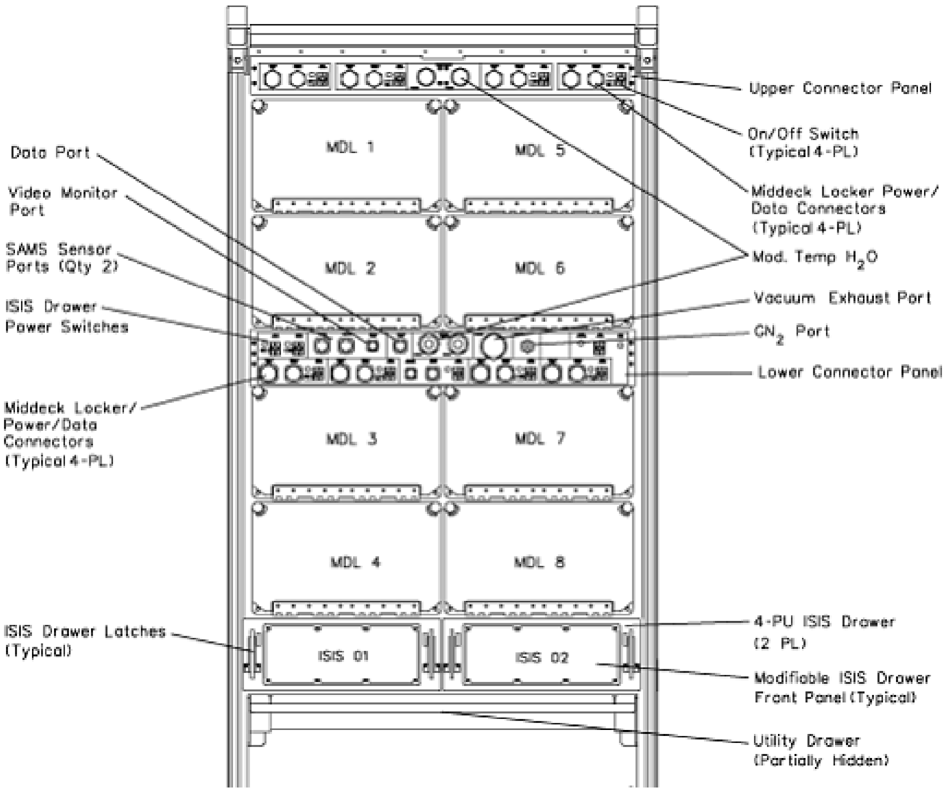

Figure 4-3 Example of an EXPRESS Rack (front view)

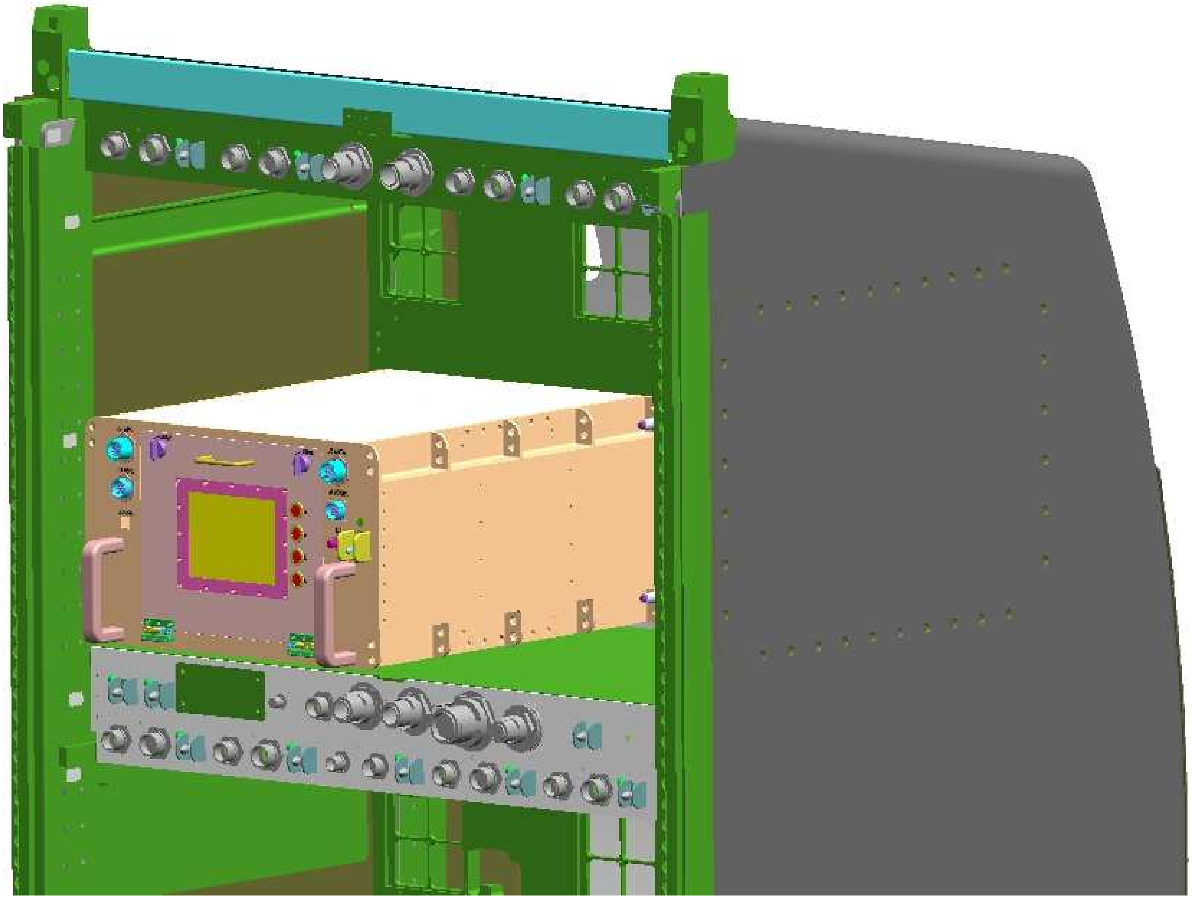

Figure 4-4 ACOP installed in an EXPRESS Rack (example of possible location)

ACOP provides these services:

1. On-orbit recording mechanism for large volumes of data at high rates
2. Play back for downlink of the recorded data at high rates
3. A crew interface for complex experiments
4. General computing facilities
5. Alternate bi-directional commanding path via the HRDL interface

ACOP will initially support a state-of-the-art particle physics detector, the Alpha Magnetic Spectrometer (AMS-02) experiment. AMS-02 uses the unique environment of space to study the properties and origin of cosmic particles and nuclei including antimatter and dark matter, to study the actual origin of the universe and potentially to discover antimatter stars and galaxies.

After the AMS-02 experiment, ACOP will remain in the US Lab as a general use computer for recording and managing large data volumes on the ISS. It will also allow a flexible and extensible control and monitoring interface for future payloads and, by using the large buffering capacity (> 1 TB), it will improve the data communication between Earth and the Space Station.

In addition to the ACOP system itself, shown in Figure 4-5 and Figure 4-6, a stowage bag will be sent to ISS with additional hard drives that can be exchanged with the hard drives in ACOP. From time to time the astronauts will perform this exchange enabling ACOP to record all of the AMS-02 data onto fresh hard drives. Once recorded, data will not be overwritten; rather the hard drives will be transported to ground as a permanent archive. The stowage bag will also contain spare parts for ACOP.

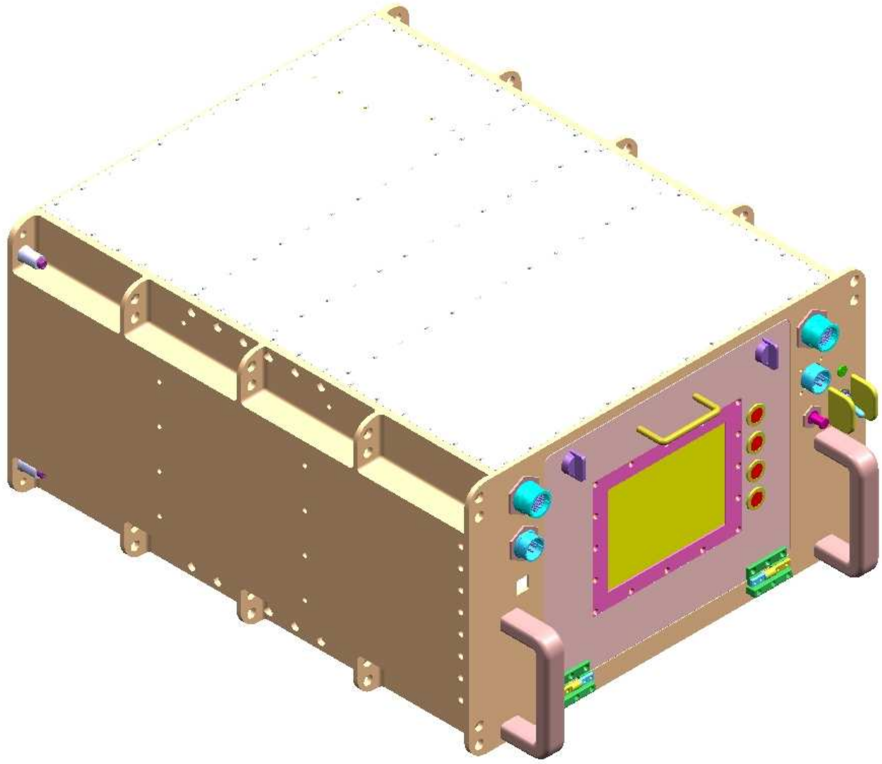

Figure 4-5 ACOP General Front View

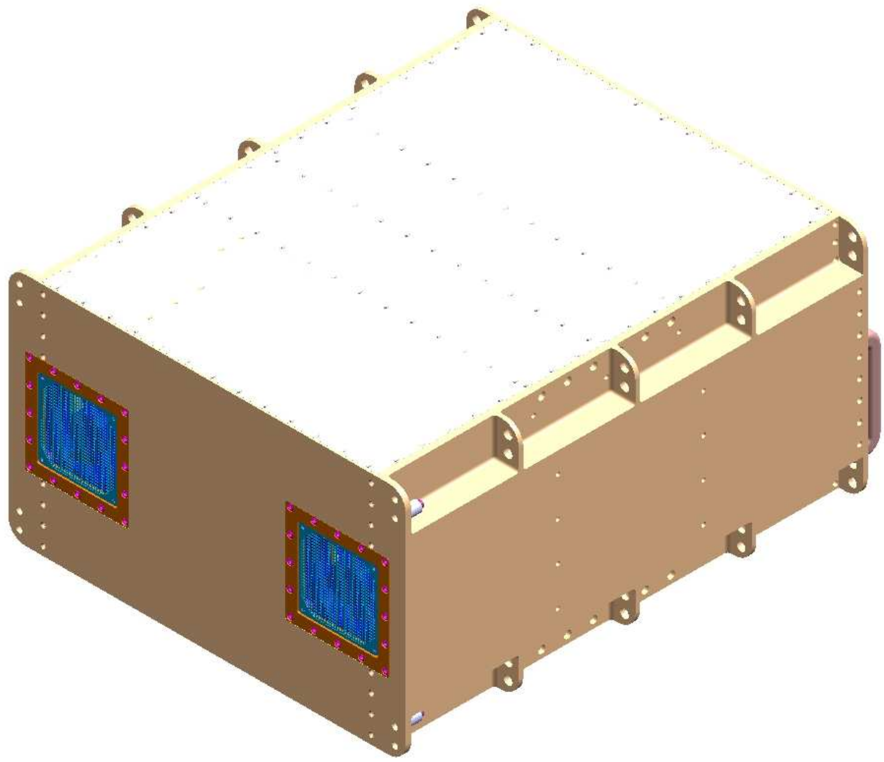

Figure 4-6 ACOP General Rear View

4.1 FUNCTION AND PURPOSE OF ACOP

ACOP has been designed to fulfill the requirements generated by the AMS-02 Collaboration. See the ACOP Common Design Requirements Document (document number: ACD-Requirements-Rev-BL, revision: baseline, date: September 2005) and the ACOP System Specification (document number: ACP-SY-CGS-001, issue: 3, date: March 2005) for a detailed description of the requirements.

The main characteristics of ACOP are summarized here below:

Capacities

1. Operates effectively in the ISS space environment.
2. Creates, on-orbit, an archive of all AMS-02 science data on removable and transportable media, using high capacity (200 GB or more) SATA hard drives.
3. Provides (based on an average data rate of 2Mbit/s) at least 20 days of recording capacity without crew intervention[1].
4. Provides (based on an average data rate of 2Mbit/s) at least 120 days of on board recording media capacity within an additional single mid-deck locker equivalent soft sided storage unit[2].
5. Recorded data is an irreplaceable archive of science data. Once recorded, data will not be overwritten; rather the hard drives will be transported to ground as a permanent archive.

Rates

6. For recording ACOP supports an orbital average data rate of at least 4Mbit/s with bursts of up to 20Mbit/s[3].
7. Supports the playback of recorded data to ground systems at selectable data rates up to at least 20Mbit/s sustained while simultaneously recording at prescribed rates (per 6.).
8. Supports an alternate AMS-02 ground commanding and housekeeping report path via the HRDL interface.
9. Supports ACOP to AMS-02 commanding at selectable data rates up to at least 20Mbit/s sustained. No requirement for simultaneous recording or playback operations at higher rates.

Interfaces

10. Provides a continuous operations display of ad hoc AMS-02 data and ACOP status for the ISS crew to monitor, via a LCD on the front panel.
11. Provides a continuous means for the ISS crew to issue ad hoc commands immediately to ACOP and to AMS-02 (without the need to un-stow or attach external equipment), by using accessible push-buttons on the front panel.
12. Provides an exhaustive diagnostic, monitoring and operations environment via the EXPRESS laptop computer.

Form

13. Housed within an EXPRESS rack locker and based on a CompactPCI 6U form factor.
14. Crew serviceable for hardware upgrades and repairs.
15. Crew serviceable for software upgrades and repairs.
16. Upgradeable and expandable using COTS subsystems.
17. Provides support of ISS system upgrades (e.g. 100bt MRDL follow on systems).

---

[1] Data capacity is completely dependent on application implementation.

[2] See note 1.

[3] The AMS-02 experiment has been designed to meet its physics goals when producing data at an average rate of 2MBit/s. Data is produced continuously. However, the physics that will be measured is unknown, and so are the peak and average data rates − 2Mbit/s average is the best estimate. Within AMS-02 a four-fold redundant 1GByte buffer (JBU) is provide to smooth the data flow and to allow for short term (less than an hour) interruptions in the data output from AMS, for example when the hard disk drives are being swapped within ACOP. After any such interruption, the data rate capability in ACOP must be able to make up for the lost time while not falling behind on the fresh data. Therefore ACOP is able to process data at a rate of at least twice the average data rate from AMS, namely 4Mbit/s.

18. ACOP is to weigh less than 35.5 kg without disks (launch weight)[4].
19. ACOP to consume less than 200 W (at 28Vdc)[5]
20. Launch compatible with MLPM mounting and dynamics.

4.2 UTILIZATION CONCEPT

The following are the key points of the ACOP operational concept as it pertains to the AMS-02 mission:

- ACOP is principally a ground operated payload
- ACOP provides the mechanism for the crew to monitor and control AMS-02. Both front panel and EXPRESS Rack laptop based interfaces are supported.
- ACOP is powered and active whenever AMS-02 is active. Only short (< 8 hours) outages.
- ACOP has continuous direct access to two physical HRDL connections (1 Tx/Rx pair plus an additional Tx, via UIP J7 connectors in other racks). By means of these interfaces:
  a. maintains a continuous Tx/Rx connection via APS to AMS
  b. provides intermittent, schedulable Tx connection for downlink.

  The additional Tx connection may be replaced by connection to the upgraded 100BaseT MRDL, when available.
- The AMS-02 TX connection may be tee'd by the APS to the HRFM/KU for direct downlink.
- As KU access is available, ACOP will be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec).
- All data transmitted by AMS-02 is recorded onto ACOP hard drives as a master copy of the AMS-02 science data.
- When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.
- The four installed hard drives will require periodic replacement by the ISS crew from the onboard stock of empty drives (30 minute operation about every 20 days)
- A batch of 20 hard drives provides at least 120 days of recording capacity.
- New batches of hard drives will be delivered to ISS and the original master copies of the AMS-02 data will be returned to earth.

[4] See ACOP Design Report for the actual mass budget

[5] See ACOP Design Report for the actual power budget

5. AVIONICS DESIGN

A general description is given in this Section. For details see the Electrical Design and Analysis Report (ACP-RP-CGS-004 Is2).

5.1 ISS AVIONICS ARCHITECTURE

The ISS Command & Data Handling (C&DH) of the ACOP and AMS-02 system is shown as Figure 5-1.

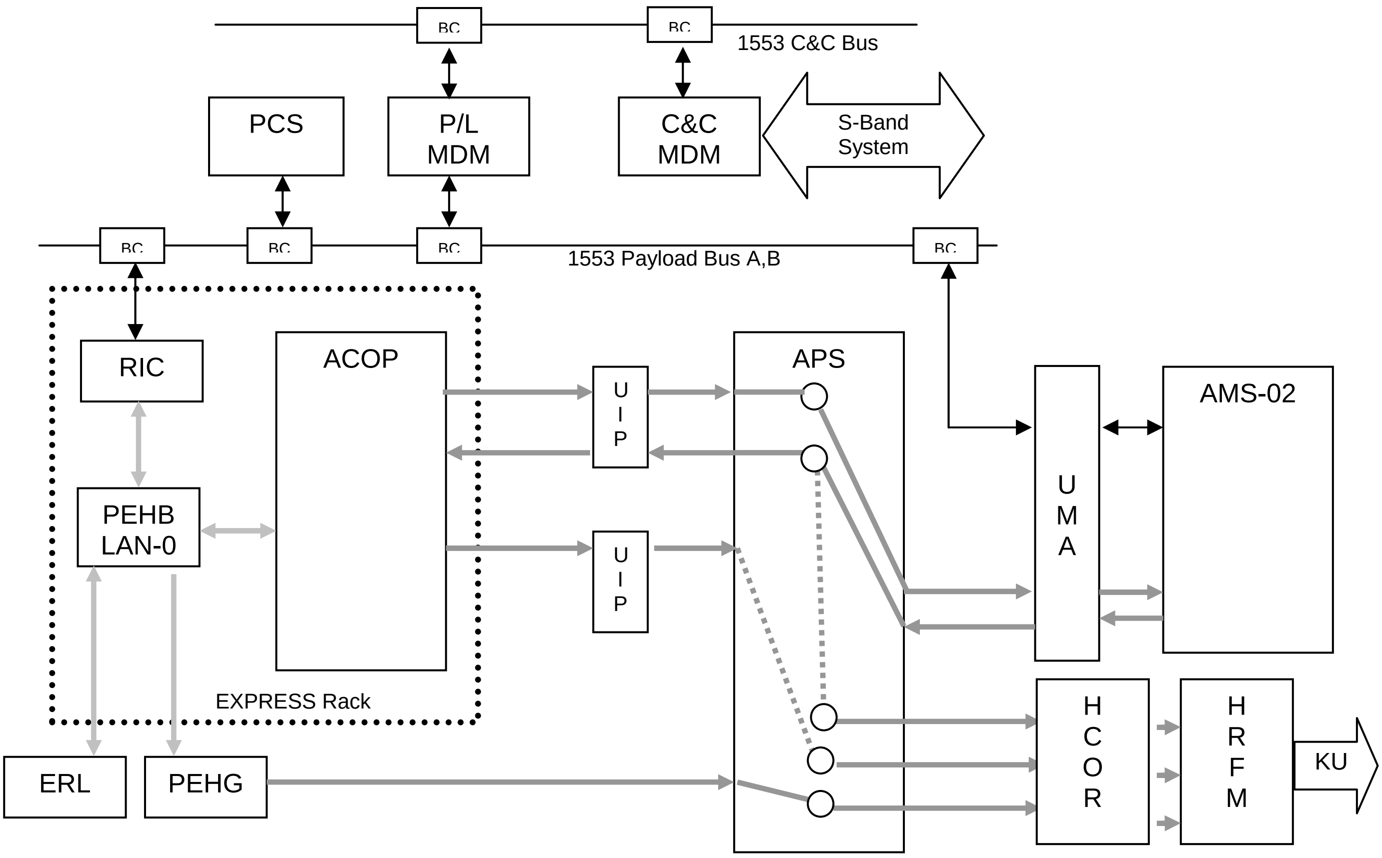

Figure 5-1 AMS-02 Avionics Architecture

Commanding and housekeeping data for ACOP is handled via the EXPRESS Rack Interface Controller (RIC). ACOP communicates with the RIC software on an Ethernet connection via the Payload Ethernet Hub Bridge (PEHB) using the Transmission Control Protocol/Internet Protocol (TCP/IP).

All ISS HRDL fibers are connected on one end to the Automated Payload Switch (APS). This device provides cross bar switching among the fiber systems of ISS. ACOP has two prime targets for HRDL transmission transfers. The first is the High Rate Frame Multiplexer (HRFM - via the High-Rate Communications Outage Recorder (HCOR). The HRFM interleaves data to the KU-Band transmission system for downlink. The second transmission target is the AMS-02 payload. The APS can be configured to tee data transmitted by AMS-02 to both the HRFM and ACOP. ACOP has a single receive source for HRDL which is the AMS-02 payload.

At all times ACOP maintains an active bi-directional connection via the HRDL interfaces to AMS-02. As KU access is made available, ACOP can be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec). All data transmitted by AMS-02 is recorded onto ACOP's hard drives as a master copy of the AMS-02 science data. When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.

5.2 ACOP AVIONICS ARCHITECTURE

The ACOP system is based on CompactPCI systems. It contains a single board computer and several interface boards (including HRDL fiber interfaces, Ethernet interfaces, USB interfaces to upgrade the operating system and programs, digital input-output and video interfaces).

ACOP will also contain four exchangeable hard disks used to archive the data and the necessary interfaces. Other parts of ACOP are a LCD screen and a simple push button interface, present on the ACOP Front Panel as part of the man-machine interface.

Fans will guarantee the internal air flow necessary for cooling. A thermal sensor network will be mounted on the chassis and PCBs to monitor the operating temperatures.

In the main chassis and front panel there are the electrical parts which include a set of digital computer hardware and software. The functional block diagram of electrical parts is shown as Figure 5-2.

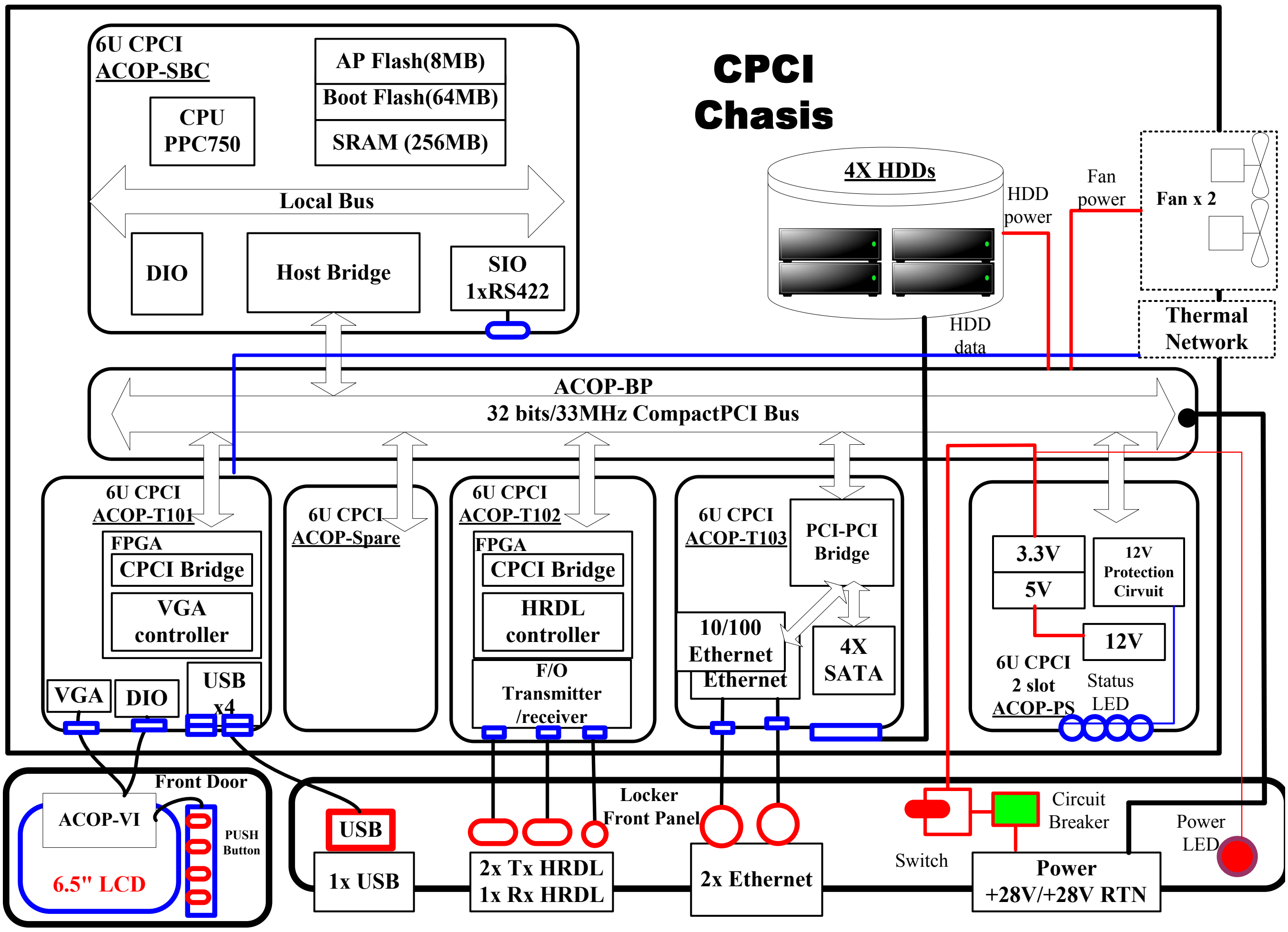

Figure 5-2 ACOP Electrical Block Diagram

The ACOP chassis includes the following modules:

- ACOP-SBC: single board computer, based on the IBM PPC 750, which provides 400Mhz speed as well as standard CompactPCI bus interfaces and acts as CompactPCI system slot.
- ACOP-T101: provides video output interface, 4 USB 2.0 interfaces, and a digital I/O (DIO) interface.
- ACOP-T102: provides 2 fiber optic transmit and 1 fiber optic receive interfaces.
- ACOP-T103: provides 2 Ethernet ports and 4 SATA ports.

- ACOP-Spare: spare slot for future expansion purpose
- ACOP-PS: double height power supply.
- 4 hard disk drives mounted in exchangeable caddies

The ACOP front panel will be equipped with:

- One aircraft style push button Circuit Breaker
- Four Momentary Push Buttons
- One On/Off Toggle Switch
- One LED monitoring power supply presence (Power Status LED)
- One HRDL Connector
- One Power Connector
- Two MRDL Connector with 10/100 base Ethernet
- One USB connector
- One LCD screen with LED backlight

5.2.1 POWER DISTRIBUTION AND POWER FEEDERS PROTECTIONS

The ACOP power distribution system includes the power input control on the locker front panel, the power distribution in ACOP backplane (ACOP-BP) and the power supply (ACOP-PS) module, as shown in Figure 5-3.

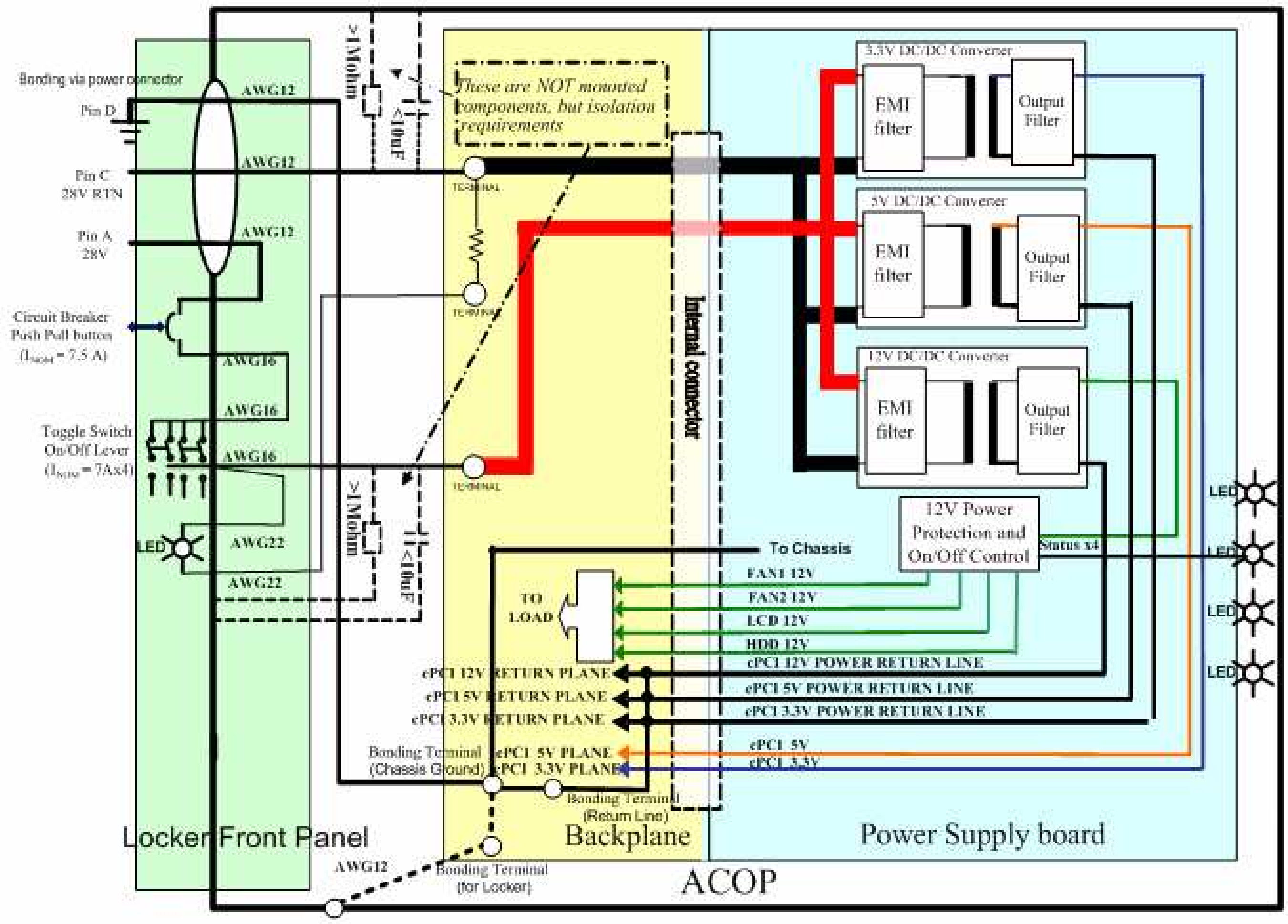

Figure 5-3 ACOP Power Distribution Diagram

The input voltage range for ACOP is 24 to 32Vdc, compliant with the +28Vdc power feeder voltage range provided by the EXPRESS Rack. The input voltage is first supplied to a circuit breaker which is used to protect wirings and downstream circuits from thermal damage that occurs during an over-current situation and as the first step of defense against electrical hazards. The circuit breaker's features include fail-safe operation, ambient temperature compensation and load protection function.

When not tripped the circuit breaker provides power to the front panel power switch. When the switch is moved to the ON position, power is provided to the system and a LED is turned on to indicate presence of 28V input voltage.

The switch output supplies the ACOP Power Supply (ACOP-PS), which is based on modular DC/DC converters implemented with hybrid integrated circuits. Each one incorporates two filters designed with output common mode filter chokes and low ESR capacitors. Three outputs provide 3.3Vdc, 5Vdc and 12Vdc power supplies with independent output regulation.
There are power terminals on ACOP-BP for distribution of regulated power to other ACOP devices. The DC-DC converters in ACOP-PS include a complete self contained EMI filter, allowing these units to meet MIL-STD-461 levels. Additional features include output common mode filtering, programmable soft start, open loop OVP protection, external synchronization inputs and an inhibit input.

The three different voltages, 3.3V, 5V and 12V, are distributed through the ACOP backplane from the ACOP-PS to the CompactPCI boards and other stand-alone devices (LCD, fans, etc.). There are protection circuits for each 12V power distribution, and the status is indicated by board mounted LEDs.

5.2.1.1 POWER INPUT CONTROL

The ACOP Locker front panel power input control includes the following functions:

- *4 pole On/Off Toggle Switch*

  This part (M8805/93-012) has been selected to meet the maximum input current requirement, including the condition of HDD startup with all 4 HDDs on simultaneously. Four poles of the switch are used, and connected in parallel. The current rating is 7A X 4 for 4 poles.

- *LED to indicate Power ON/OFF status*

  A green LED (JANTXM19500/521) is mounted on the Locker front panel to indicate Power ON/OFF status. A resistor (mounted on ACOP-BP) is connected in series to this LED to limit its current.

- *Aircraft style push button Circuit Breaker for input over current protection*

  The estimated maximum input power of ACOP is 113.45W (not including circuit breaker and wire losses). The estimated minimum input voltage of DC/DC Converters is:

  24V (Vin lower bound) – 0.3V (CB voltage drop) – 0.2V (Wire loss drop) = 23.5V.

  Therefore, the maximum input current is Pin(max) / Vin(min) = 113.45 / 23.5V = 4.83A. A 7.5A Circuit Breaker (MS 3320-7 1/2) has been selected to meet the requirements.

5.2.1.2 POWER SUPPLY MODULE

The ACOP-PS module is CompactPCI form factor, installed in the ACOP backplane, and provides the power source for ACOP electronics parts. The ACOP-PS includes the following functions:

- Convert input power (DC 28V) to meet the power requirements of all ACOP electronics parts.
- Isolation between 28V input from ISS and output load.
- Protection of each power output (3.3V, 5V, 12V)
- 3.3V and 5V power source with a function of remote sensing.
- Provide on/off control of each 12V power distribution to Fan1, Fan2, and LCD.
- Provide protection status of each 12V power distribution to system, and indicate by board mounted LEDs.
- Provide two Dallas thermal sensors for each DC/DC Converter.

5.2.2 POWER-ON SEQUENCING

The ACOP-SBC board will provide a power monitor circuit for both the 3.3V and 5V supplies: during power up, the 3.3V power monitor circuit will hold the ACOP-SBC in reset until the power is stable. The 5V power monitor signal will be latched when faulted and the latched result will be provided as input to the CPU for software read and then clear operation.

5.2.3 ACOP INTERNAL LAYOUT

Figure 5-4 shows the internal layout of boards and components inside ACOP as it will be seen by the crew when the front panel is open.

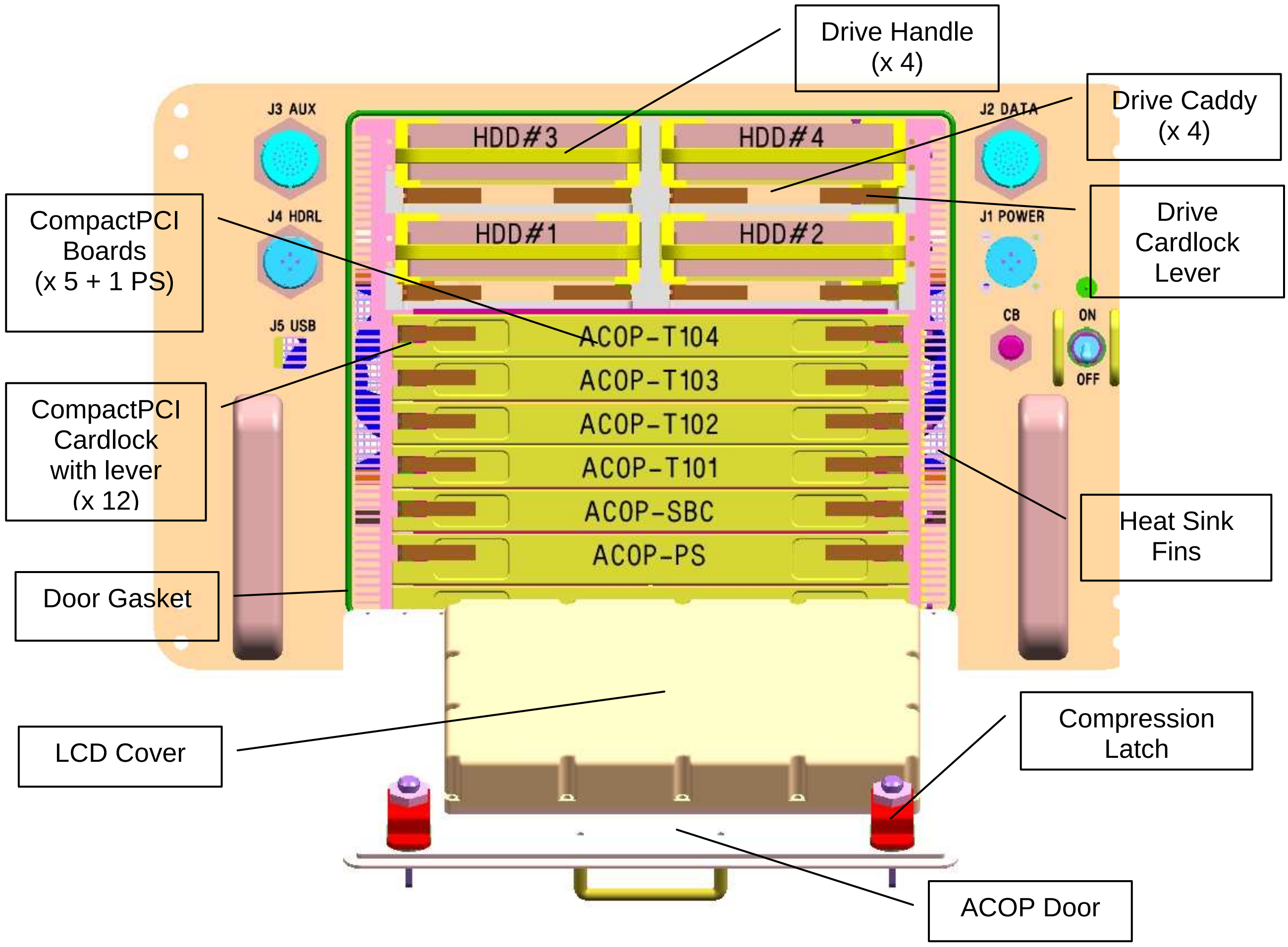

Figure 5-4 ACOP Main Components

The upper part of the chassis will be occupied by 4 Drive Caddies holding Serial ATA hard drives. The Drive Caddies will be fixed to the chassis by means of cardlock retainers provisioned with lever arms to minimize the crew effort to replace them. Power and data interface to each Drive Caddy is provided by means of a blind mate connector placed on the rear side.

The CompactPCI boards and the power board will be hosted in the lower section of the chassis. These boards will also be fixed to the chassis by means of cardlock retainers.

The main characteristics of the ACOP chassis assembly are:

- 6U card cage for 5 double Eurocard CompactPCI boards.
- Conduction cooling and wedge-locks for CompactPCI boards and power supply board.
- Double height power supply slot.
- Mounting provisions for CompactPCI backplane.
- 4 hard drives with caddies that can be removed from the chassis

The CompactPCI bus combines the performance advantages of the PCI desktop architecture with the ruggedness of the Eurocard form factor, a widely used standard within the industry for over 20 years. The Eurocard board provides more secure connectors and more available space for professional embedded platforms than the PCI cards in desktop computers. The CompactPCI standard has widely been accepted for a large spectrum of applications.

6. SOFTWAREDESIGN

6.1 SCOPE OF THE SOFTWARE

ACOP-SW is the entire body of embedded software running on the ACOP hardware. ACOP-SW consists of three components:

- ACOP-SYS-SW providing low level functionality,
- ACOP-APP-SW providing the mission explicit application software functions on the ACOP hardware,
- ACOP-ERL-SW software developed by the ACOP project but which executes on the EXPRESS Rack Laptop.

The ACOP-SYS-SW consists of eCos, an open source embedded operating system and LINUX Operating System kernel (version 2.6). Drivers under LINUX OS for all the CompactPCI boards and the storage devices will be used.

The ACOP-APP-SW will be based on a cooperative multitasking system which moves messages among tasks. Tasks are used to provide: interfaces to external devices, functions (such as recording), data management (telemetry queue manager), and automation of functions (master control task).

For a detailed description, see the Software Architectural Design Document (ACP-TN-CGS-003 Is1).

6.1.1 ACOP-SYS-SW

ACOP-SYS-SW implements the following main functions:

- Boot ROM monitor providing boot strapping operations and low level file transfer functions.
- Initialization of the ACOP hardware.
- Operations of the ACOP hardware interfaces via device drivers.
- Exception handling.
- Diagnostic and system self-tests.
- Management of data storage devices and file systems.
- External command processing for system commands.
- Execution and control of ACOP-APP-SW.

6.1.2 ACOP-ERL-SW

ACOP-ERL-SW implements a complete ISS crew interface on the EXPRESS Rack Laptop for ACOP monitoring and commanding.

6.1.3 ACOP-APP-SW

ACOP-APP-SW implements the following main functions:

- Monitoring of resources and environment relevant to ACOP Health and Status.
- Functional interfaces to ISS avionics C&DH systems.
- Functional interfaces to the ISS HRDL interfaces.
- Data recording.
- Data playback.
- Detailed data management.
- Detailed management of data contents with regard to external systems.
- External command processing for applications commands.
- A menu driven Man-Machine Interface using the LCD and push buttons.

7. MECHANICAL DESIGN

7.1 LOCATION AND FORM FACTOR

ACOP can be installed in any one of the eight single height locations for Mid-Deck-Lockers (MDL) of an EXPRESS Rack. Figure 7-1 below shows one of the possible locations. The ACOP locker provides blind mating with the back plate of the EXPRESS rack using Type-B captive fasteners while power, data, and other avionics connections are made with external cables to the ACOP front panel.

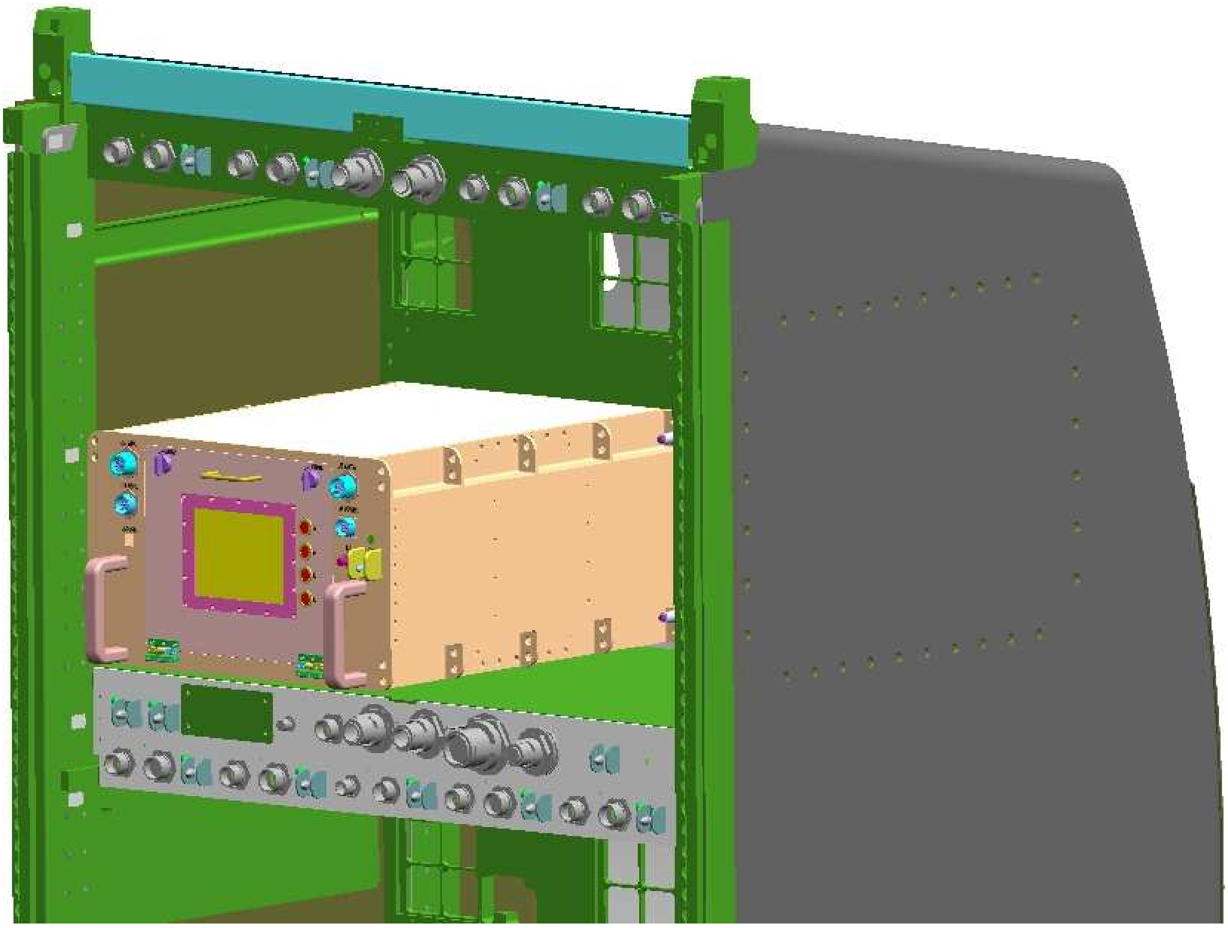

Figure 7-1 Example EXPRESS Rack Location

7.2 NOMENCLATURE

Figure 7-2, Figure 7-3, Figure 7-4, Figure 7-5, and Figure 7-6 below introduce the nomenclature for key parts of ACOP.

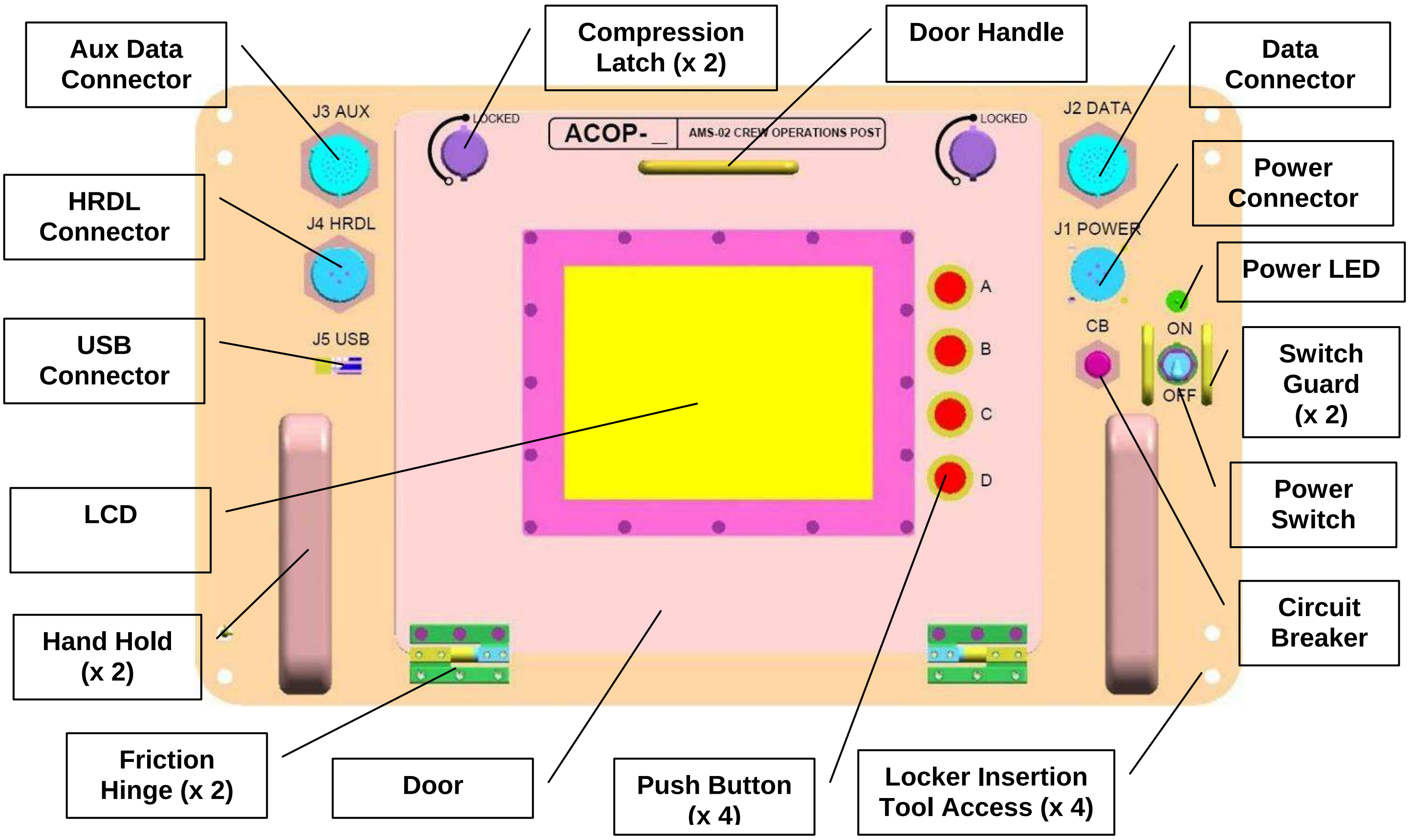

Figure 7-2 Front Panel Nomenclature

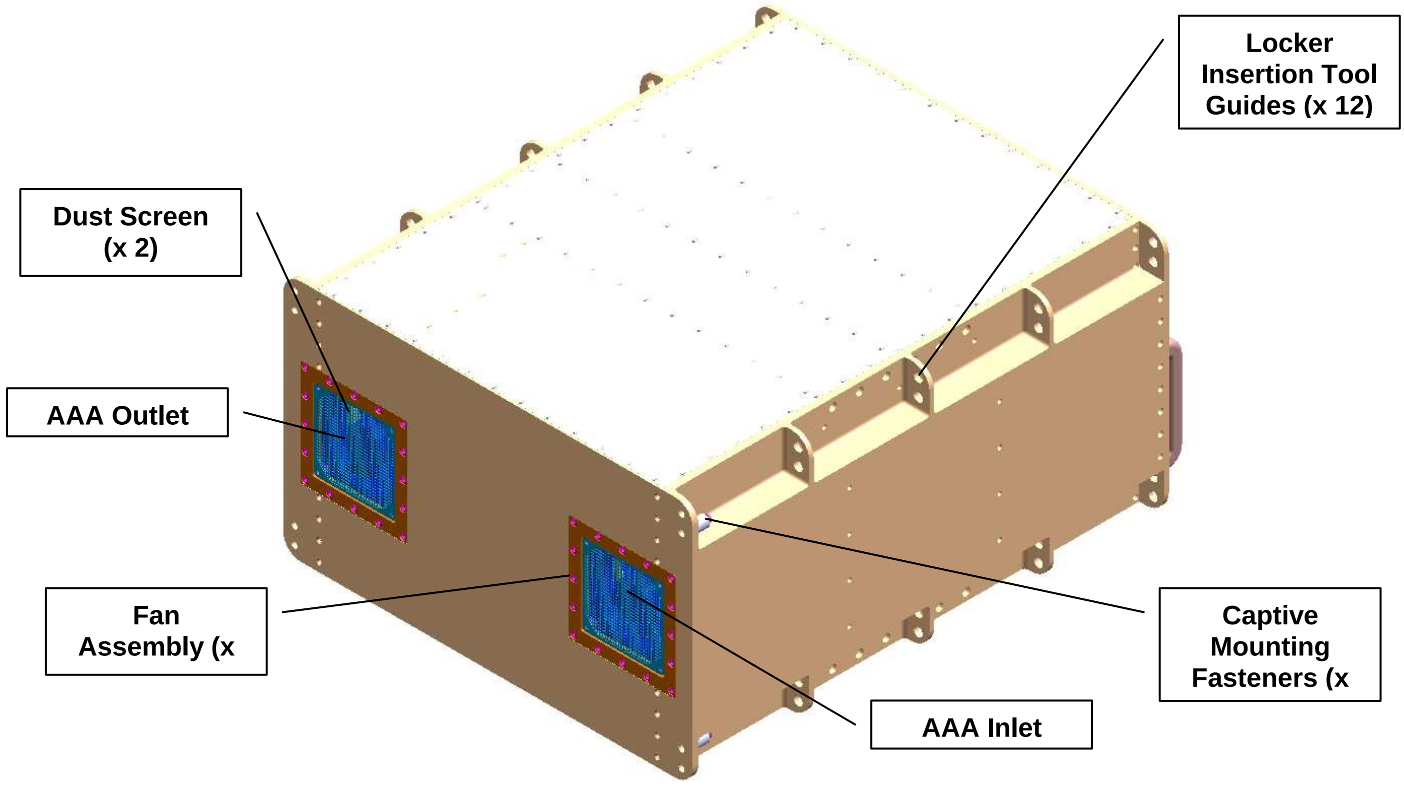

Figure 7-3 Back Panel Nomenclature

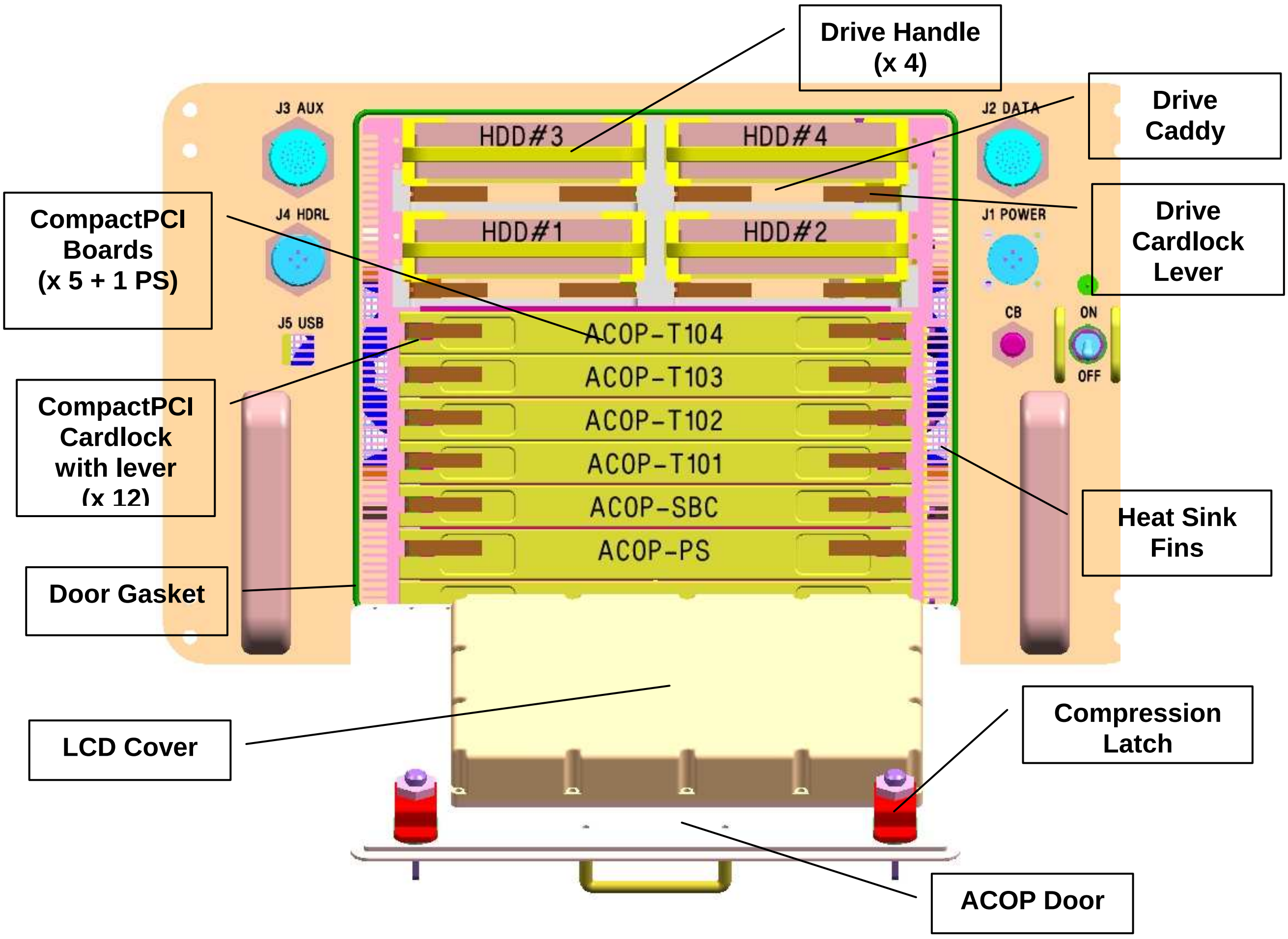

Figure 7-4 Front Interior Nomenclature

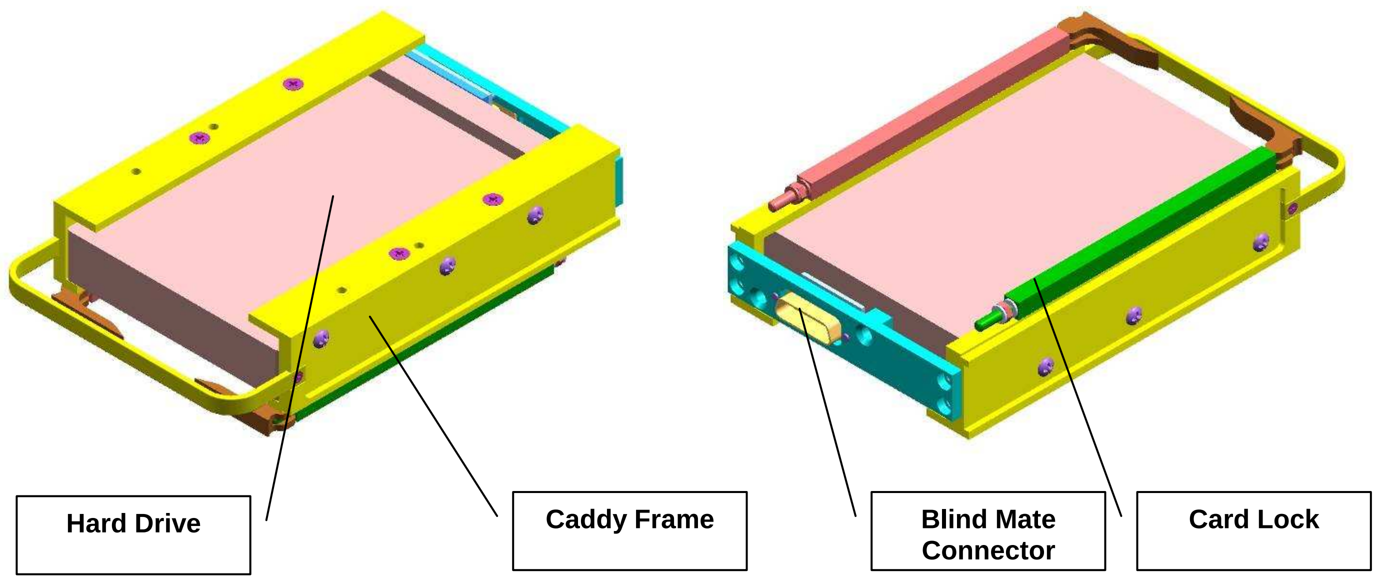

Figure 7-5 Drive Caddy Nomenclature

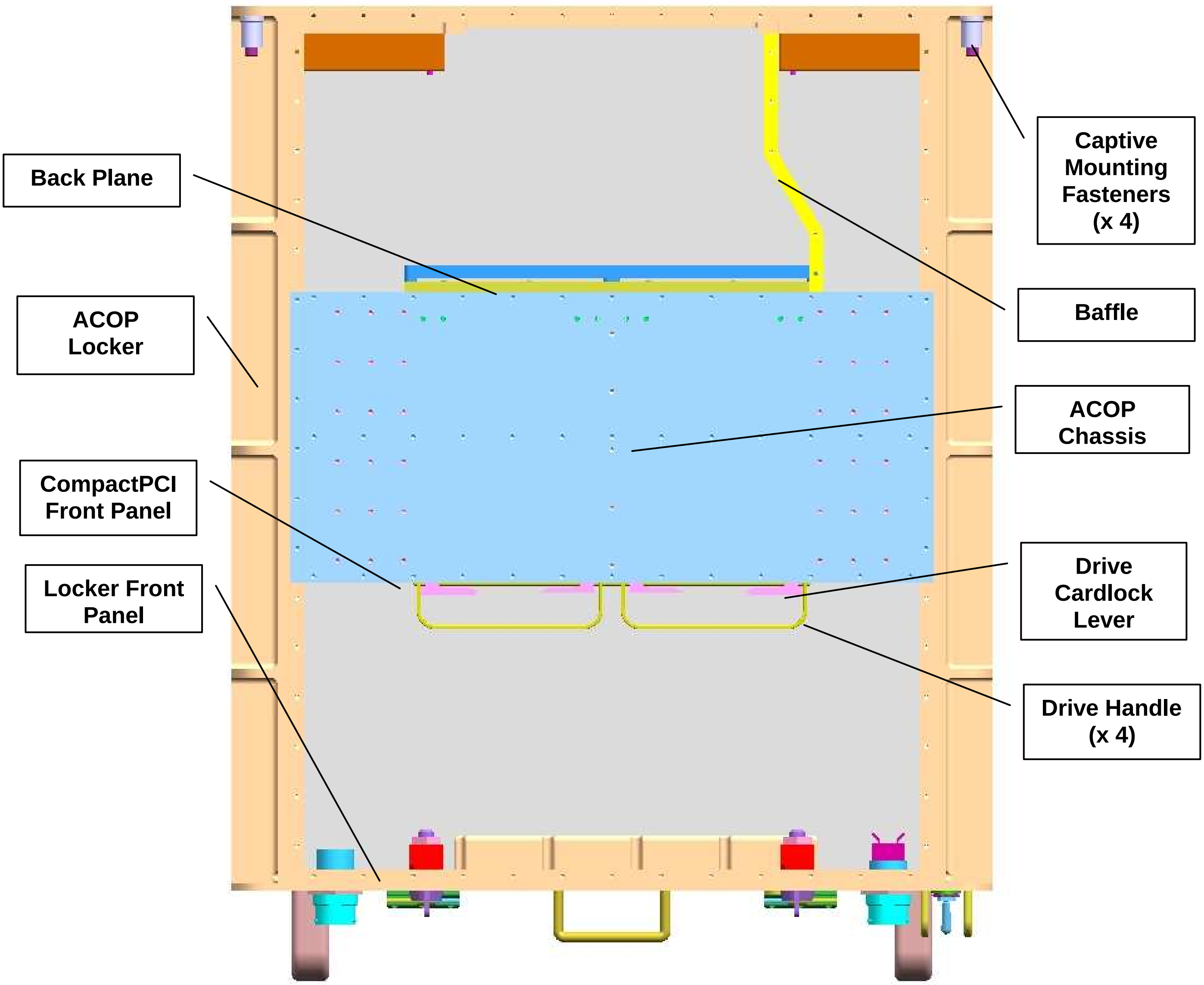

Figure 7-6 Top Interior Nomenclature

7.3 DIMENSIONS

Figure 7-7 and Figure 7-8 show the dimensions of major external items on ACOP.

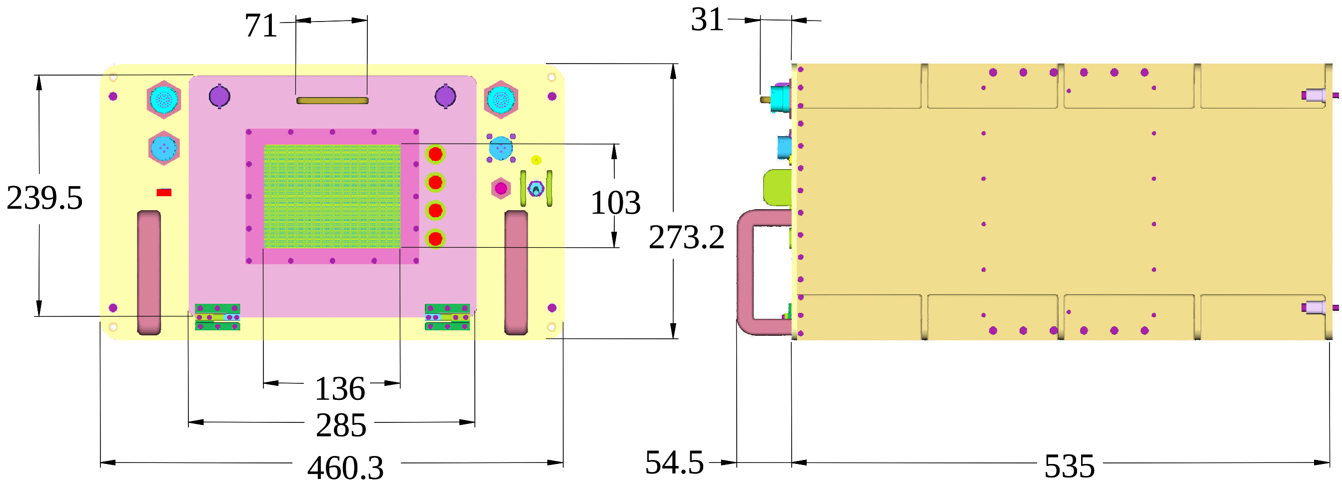

Figure 7-7 ACOP Door Closed Dimensions (mm)

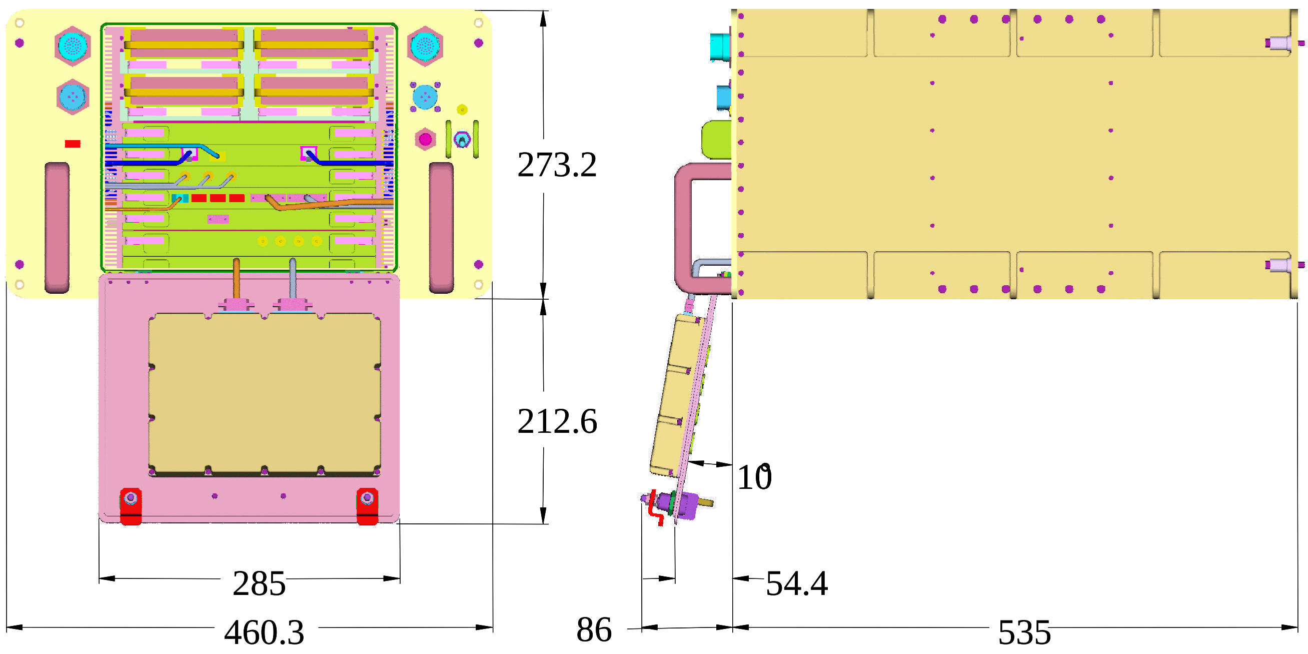

Figure 7-8 ACOP Door Open Dimensions (mm)

7.4 MECHANICAL ARCHITECTURE

The mechanical structure of ACOP consists of an outer structure (Locker) and an inner structure (Chassis). All the parts will be made of aluminum alloy of type appropriate for structural and thermal considerations.

Surface treatments used:

- Clear anodizing class 1 according to Spec.MIL-A-8625
- Alodine 1200 class 3 according to Spec.MIL-C-5541 (for mating surfaces which must guarantee low electrical resistivity).
- Off-white semi-gloss polyurethane topcoat for Front Panel and Door.

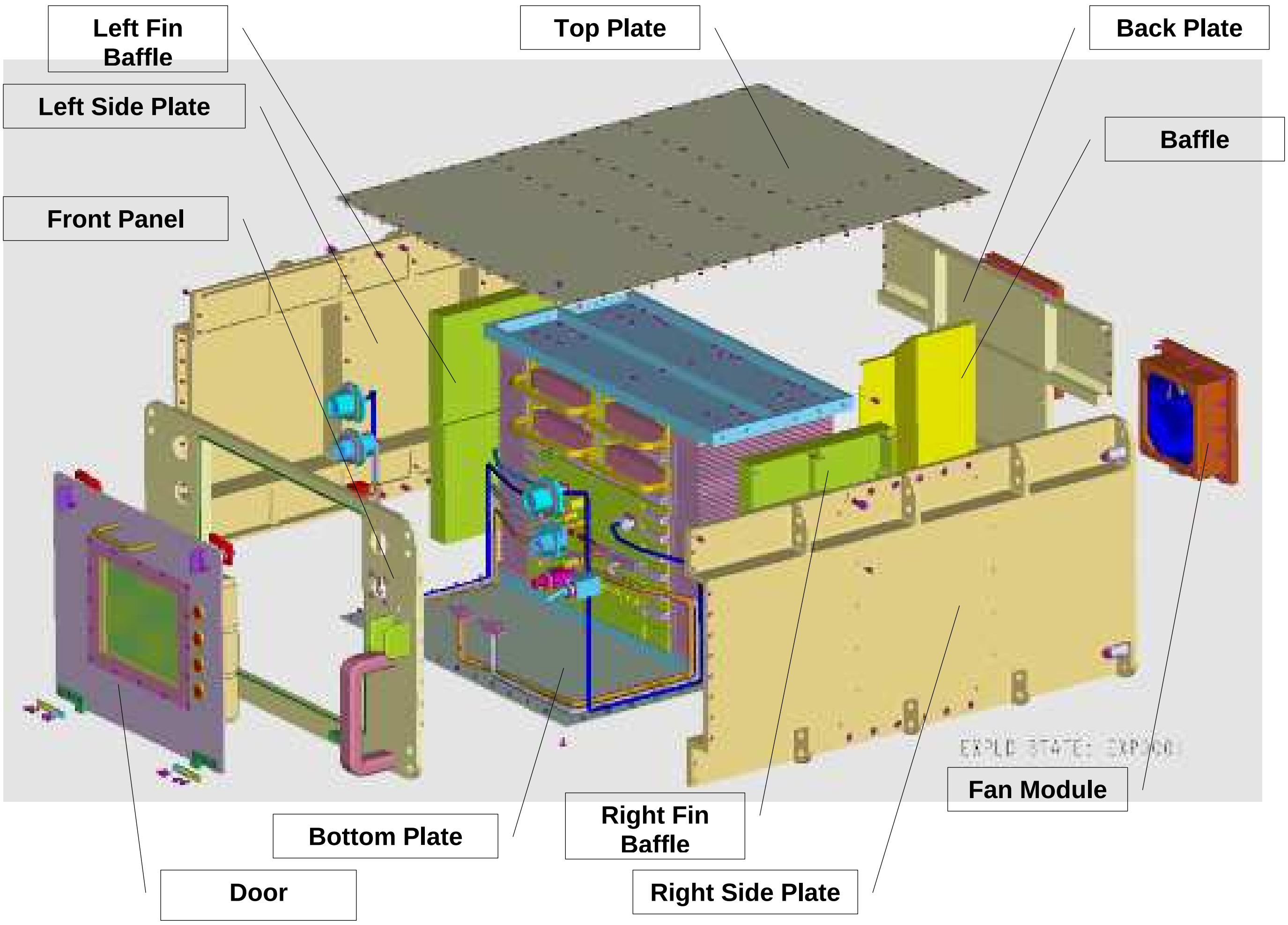

Figure 7-9 ACOP Main Component Exploded View

7.4.1 ACOP LOCKER

The Locker (made up of a Front Panel, Right Side Plate, Left Side Plate, Back Plate, Top Plate, and Bottom Plate – see Figure 7-9) is the interface of the ACOP structure providing external mechanical mounting connections, mounting for electrical connectors, an interface to the EXPRESS Avionics Air Assembly (AAA) providing cooling air, mountings for the opening front door, and internal mountings for the Chassis and associated hardware.

Unless noted the Locker is assembled using A286 screws into self locking helicoils .

The Locker provides mounting for:

- Two Fan Modules.
- A Door with Hinges, Door Handle, LCD, and Push Buttons.
- Four Type-B captive fasteners[6] securing ACOP into the EXPRESS rack as well as the tool guides for the locker insertion tool.
- External avionics connectors for HRDL, Power, Data, Auxiliary Data, and USB.
- Hand holds to assist handling and installation as well as attended operations.
- Internally the Chassis and air flow baffles.

7.4.1.1 LOCKER MOUNTING HARDWARE

Captive fasteners are used to attach ACOP to the EXPRESS rack (see Figure 7-10). Mounts are provided in the Locker for both Type A and Type B fasteners as defined by the EXPRESS IDD. Only the Type-B fasteners will be installed in ACOP.

CS5108C4-5 and CSR538-5 by F.I.T. INC (or equivalent) will be utilized. Data sheets are available.

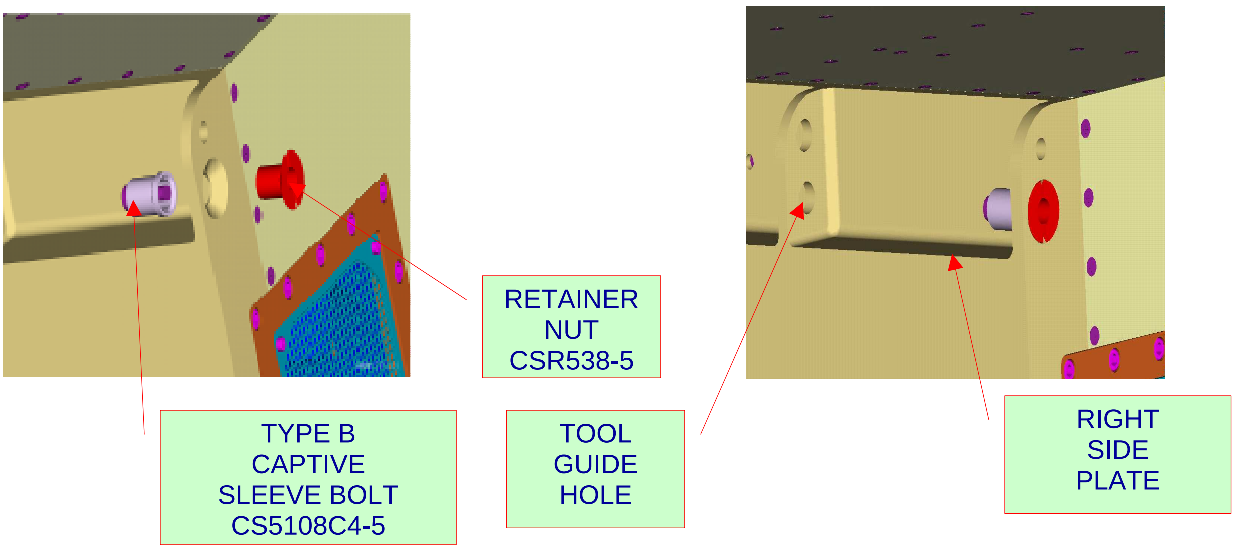

Figure 7-10 Type B Captive Fastener Detail

[6] Provisions are made for Type-A fasteners as well however these fasteners will not be installed on the ACOP hardware.

7.4.1.2 FRONT PANEL

The Front Panel (see Figure 7-9) consists of a machine milled plate and provides the mounting point for (see Figure 7-2):

- HRDL Connector – A military style connector providing attachment of fiber optic cables.
- USB Connector – An access port for USB device attachment.
- Aux Data Connector – A military style connector providing a second Ethernet connection.
- Data Connector – A military style connector providing Ethernet connectivity
- Power Connector – A military style connector providing 28 volt power supply.
- Power LED – An indicator that 28 volts is supplied to ACOP.
- Circuit Breaker – A circuit protection device.
- Power Switch – Power on/off switch with Switch Guards.
- Hand Holds – Providing aid to handling and installation as well as assistance to operations.
- Door Gasket – Providing an air seal and EMI protection (see Figure 7-4).
- Friction Hinge – Mechanism to support the Door.

The Front Panel Plate is integrated to the Top Plate, Bottom Plate, and Right and Left Side Plates by A286 flat head screws, size #4-40UNC.

7.4.1.3 BACK PLATE

The Front Panel (see Figure 7-9) consists of a machine milled plate. The Back Plate together with the two side plates provides the mounting points for (see Figure 7-3):

- Two Fan Assemblies mounted (using captive fasteners) in the AAA Inlet and AAA Outlet ports.
- Four Type-B Captive Fasteners.

The Back Plate is integrated into the Top Plate, Bottom Plate, Right and Left Side Plates, and Baffles by A286 flat head screws, size #4-40UNC.

7.4.1.4 RIGHT SIDE PLATE

The Right Side Plate (see Figure 7-9) consists of a machine milled plate. The Right Side Plate provides the (see Figure 7-3):

- Mounting point for two of the four Type-B captive fasteners[7] for mounting ACOP into the EXPRESS rack. Alternative mounting point for Type-A captive fasteners.
- Eight Locker Insertion Tool Guides (four active guides for Type-B) top and bottom.

The Right Side Plate is integrated into the Top Plate, Bottom Plate, Front Panel Plate, Baffles by A286 screws, size #4-40UNC, and Chassis by A286 screws, size #10-32UNF.

7.4.1.5 LEFT SIDE PLATE

The Left Side Plate (see Figure 7-9) consists of a machine milled plate. The Left Side Plate provides the (see Figure 7-3 for symmetrical side):

- Mounting point for two of the four Type-B captive fasteners for mounting ACOP into the EXPRESS rack. Alternative mounting point for Type-A captive fasteners.
- Eight Locker Insertion Tool Guides (four active guides for Type-B) top and bottom.

[7] See note above.

The Left Side Plate is integrated into the Top Plate, Bottom Plate, Front Panel Plate, Baffles by A286 screws, size #4-40UNC, and Chassis by A286 screws, size #10-32UNF.

7.4.1.6 TOP PLATE

The Top Plate (see Figure 7-9) consists of a machine milled plate. The Top Plate provides closure to the locker. The Top Plate is integrated into the Right and Left Side Plates, Front and Back Plates, Baffles and Chassis by A286 flat head screws, size #4-40UNC.

7.4.1.7 BOTTOM PLATE

The Bottom Plate (see Figure 7-9) consists of a machine milled plate. The Bottom Plate provides closure to the locker. The Bottom Plate is integrated into the Right and Left Side Plates, Front and Back Plates, Baffles and Chassis by A286 flat head screws, size #4-40UNC.

7.4.2 FRONT PANEL DOOR

The Door provides an opening to access the internals of ACOP. When opened there is access to exchange: hard drives, CompactPCI boards, the power supply, and to handle the internal wire harness if needed.

The Door (see Figure 7-9) is an assembly as shown in Figure 7-11 below.

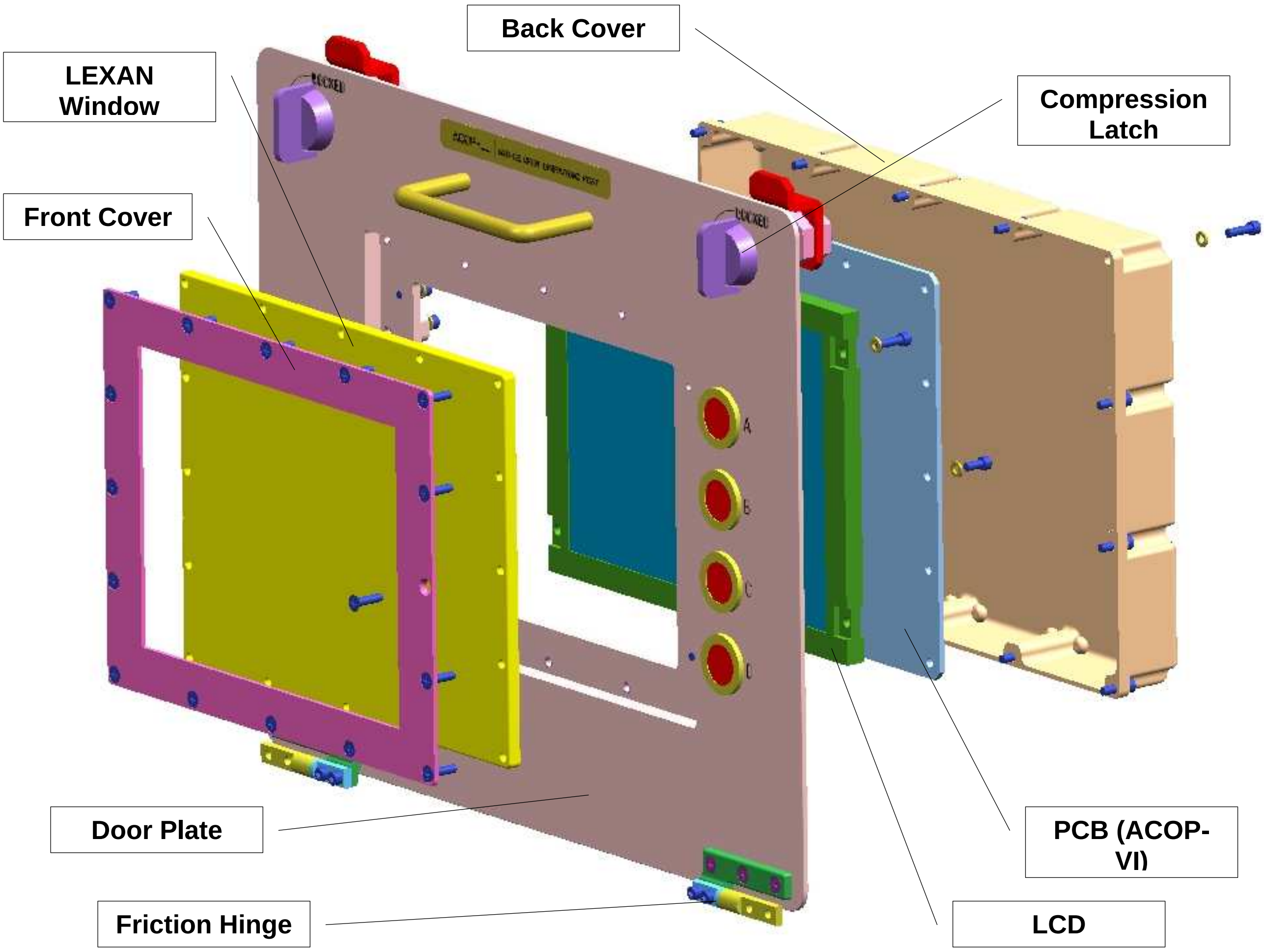

Figure 7-11 Door Assembly Front View

The Door assembly (see Figure 7-9, Figure 7-11, and Figure 7-12) consists of:

- A machine milled Door Plate.
- An aluminium machine milled Front Cover retaining a protective 5mm thick LEXAN window.
- Compression Latches to provide the force to hold the Door closed against the gasket.
- Friction Hinges fabricated of AISI 316 to provide the Door motion as well as to hold the Door in a stable state in low gravity.
- LCD for graphic images.
- ACOP-VI PCB for avionics functions.
- Four Push Buttons for operations input.
- Back cover providing containment and protection to electronics.

The LCD, PCB, and Back Cover are assembled from the back side of the Door Plate by screws size #4-40UNC (see Figure 7-12). The Front Cover and LEXAN are assembled from front side of the Door Plate by screws size #4-40UNC.

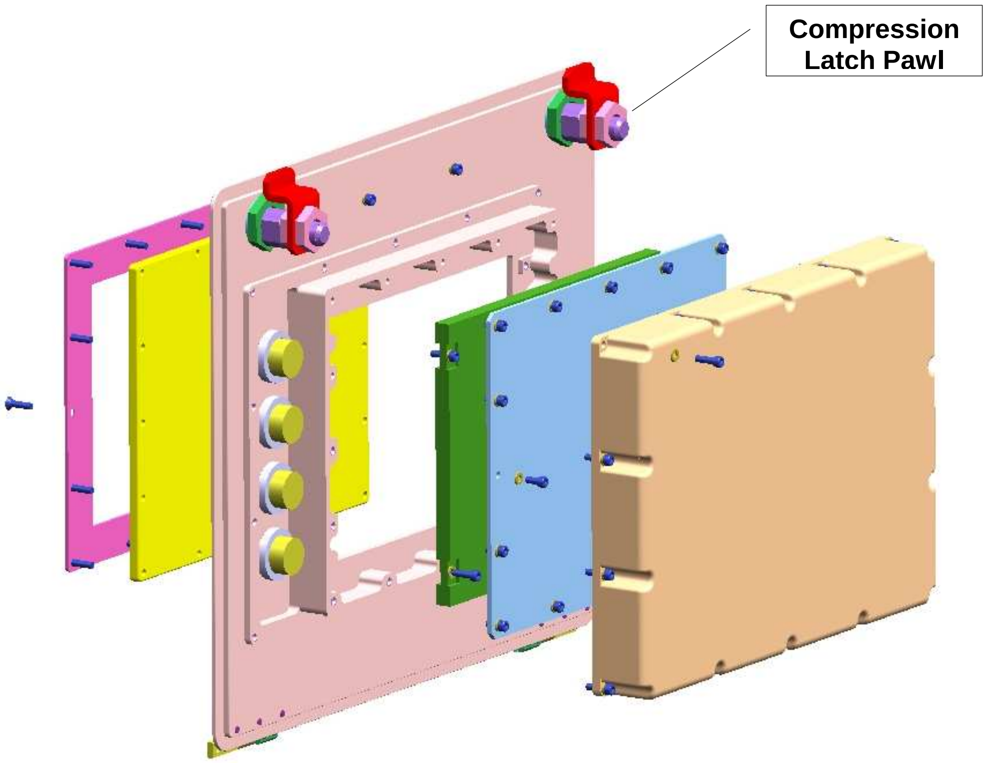

Figure 7-12 Door Assembly Rear View

7.4.2.1 LATCH

Two Compression Latches (see Figure 7-11) by Southco (E3-57-42) made of stainless steel (AISI 316) are mounted on the upper two corners of Door to close and tighten the door against the gasket. The latch pawls utilize the inside of the Front Panel as a strike plate.

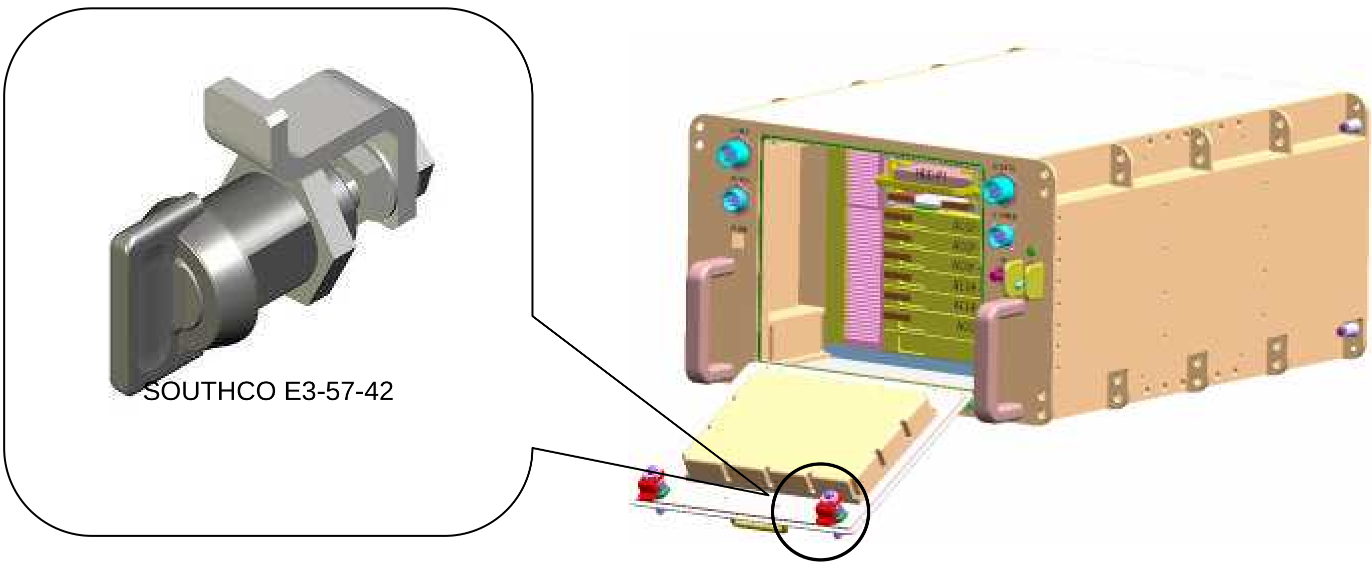

Figure 7-13 Door Compression Latch

7.4.2.2 FRICTION HINGE

Two 6 kg-cm torque Friction Hinges (see Figure 7-14) made of stainless steel 316 are the mechanism to open and hold the Front door. The hinges are mounted using small adapters that provide positioning as well a providing a stopping function.

- Producer: Chien-Fu Enterprise Co.
- Part No. : CFHG16
- Material: AISI 316
- Torque : 5~7 kg-cm

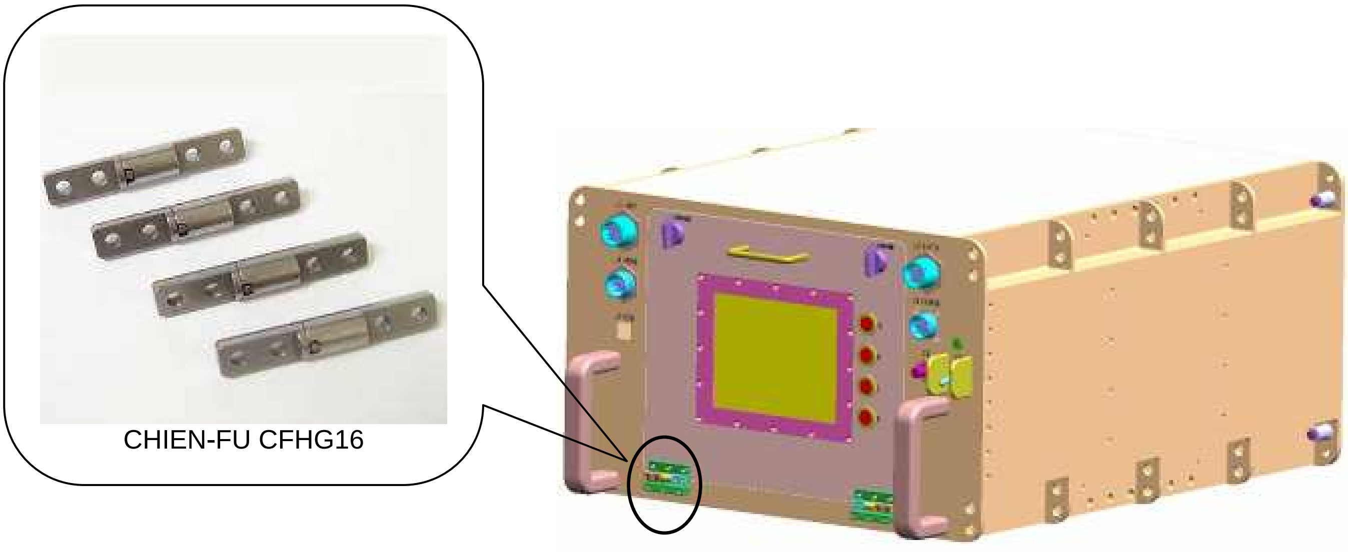

Figure 7-14 Door Friction Hinge

The Door can be opens down to the maximum angle of 170 degrees and is stopped by a block on hinge (see Figure 7-15).

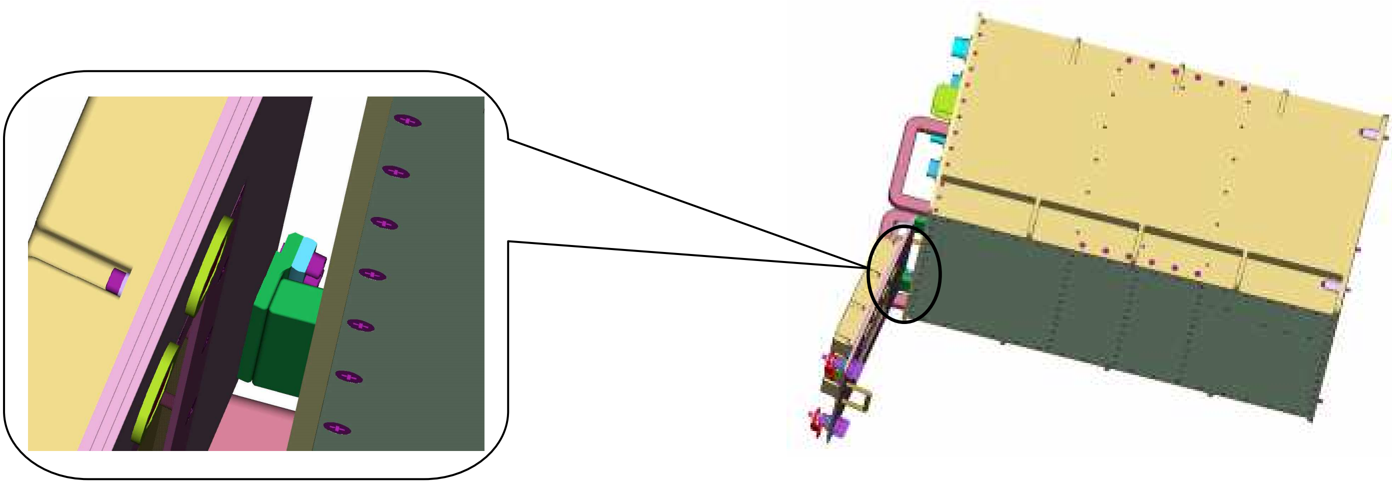

Figure 7-15 Hinge Stop

7.4.2.3 DOOR GASKET

An EMI sealing gasket is set in a groove in the Front Panel between Door and Front Plate to prevent EXPRESS AAA cooling air from escaping to the ISS cabin and to increase electric conductivity.

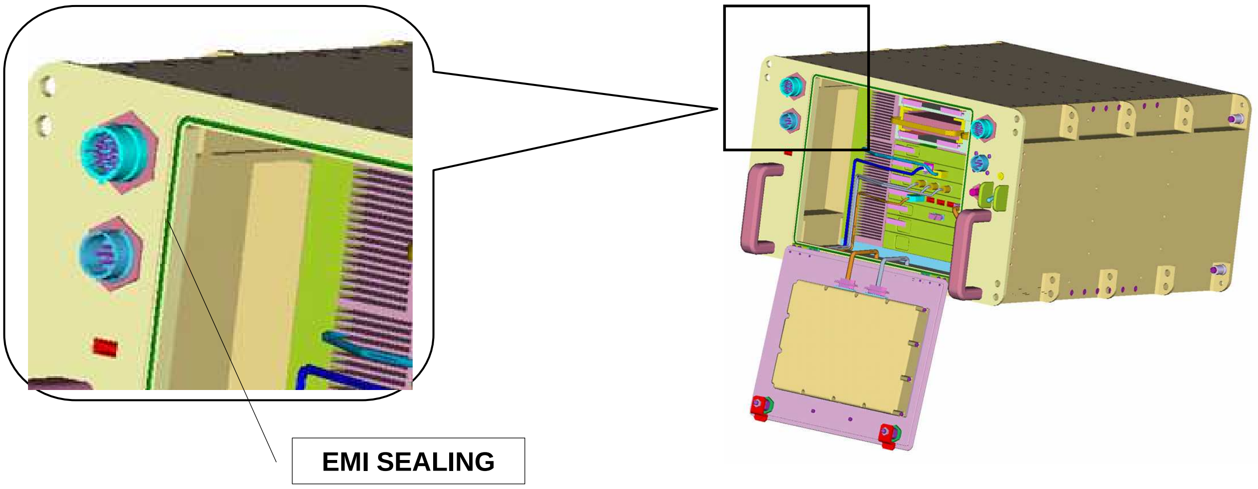

Figure 7-16 Door Gasket

7.4.2.4 FAN ASSEMBLIES

The ACOP Back Plate has inlet and outlet ports for Avionics Air Assembly (AAA) cooling air. These ports are located to coordinate with the appropriate openings in the EXPRESS rack back plate. Mounted in these ports are Fan Assemblies to provide cooling air flow to the ACOP Chassis and avionics systems.

Figure 7-17 shows the exploded view of the Fan Assembly external components. The Fan is mounted in the Fan Frame using captive fasteners. The debris Screen is attached to the Fan Frame using 4 captive fasteners (CA2261 series with retainer ring CA2210 series). The Fan Frame is attached to the Back Plate with 16 captive fasteners (CA2261 series with retainer ring CA2210 series , size#6-32UNC) to support on board maintenance and replacement.

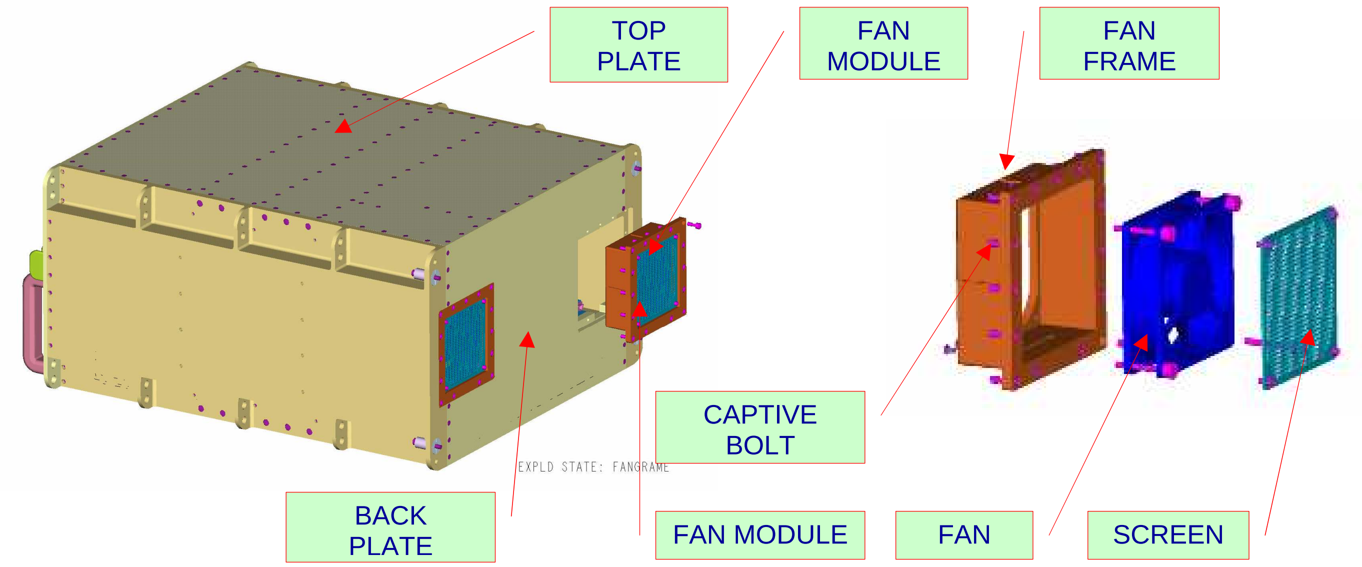

Figure 7-17 Fan Assembly External Details

The interior details of the Fan Assembly are shown in Figure 7-18. The fan power and instrumentation systems are connected using a blind mate connector to support maintenance of the Fan Assembly.

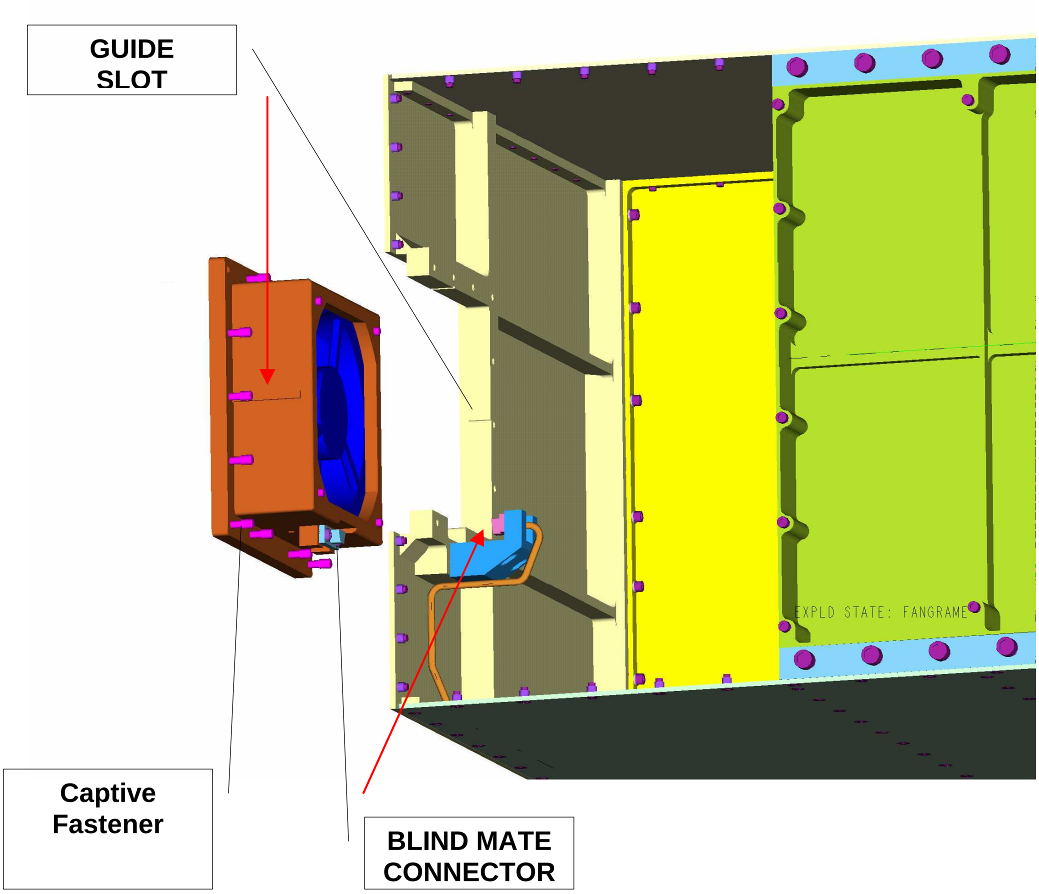

Figure 7-18 Fan Assembly Interior Details

7.4.3 CHASSIS

The Chassis provides the internal support of the electrical components (CompactPCI cards, hard drives, power supply, and backplane). Additionally the Chassis provides the thermal path (heat sink) to the heat dissipation fins.

The Chassis consists of 6 mechanical parts as shown in Figure 7-19.

- Chassis Top and Bottom Plates - Connects the Chassis structure to the Locker.
- Right and left Heat Sink Fins - Air cooling fins as well as card guides for CompactPCI and power supply boards.
- Top and Bottom Caddy Plates – Hard drive guides, thermal path, and mount points for blind mate connectors.

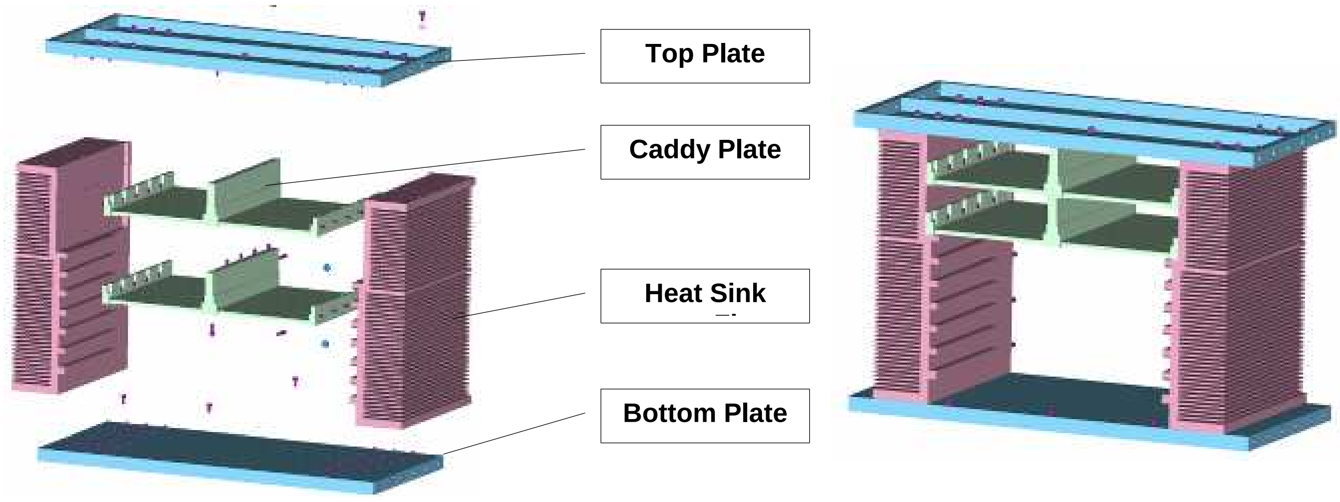

Figure 7-19 Chassis Components

Not strictly part of the Chassis but presented here are three air handling baffles. Shown in Figure 7-9 are:

- Right and left Fin Baffle - Blocks the air gap between Chassis and the Locker.
- Baffle - Separates inlet air from outlet air.

7.4.4 AVIONICS MECHANICS

This section addresses the mechanical issues of the avionics systems in ACOP. Covered in this section are the card locks, hard drive caddy details, board mechanics, and card stiffeners.

7.4.4.1 CARD LOCKS

CALMARK LE260 Card locks (see
Figure 7-5) are used to provide clamping of the CompactPCI PCBs, Power Supply PCB, and Drive Caddies to the thermal interfaces (the Heat Sink Fin's inner wall and the Caddy Plates). The clamping force is approximately 125 lb (556 N).

Insertion and extraction operations (see Figure 7-20) are provided using hand operated levers (no tools). The levers operate as board extractors (but provide no assistance with assertion). The details are shown in Figure 7-21.

Special considerations (TBD) will be made for the surface treatment of the channel areas forming the card guides into which the card locks are inserted to reduce binding of the card locks in the channel. The surface treatment of the card locks is hard anodized.

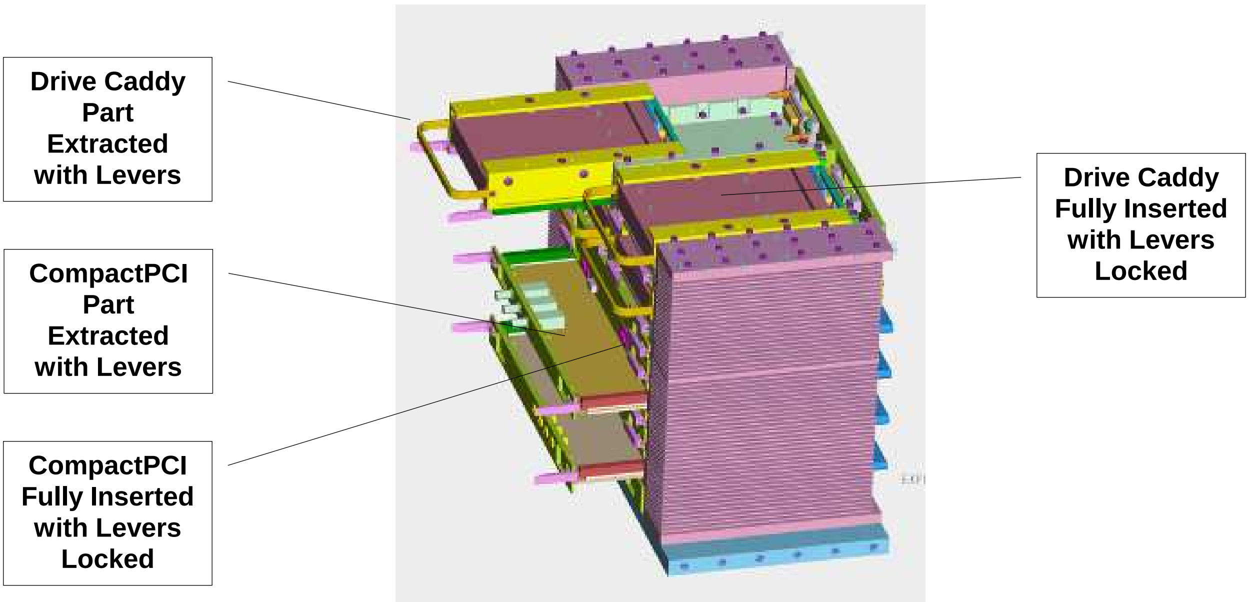

Figure 7-20 Card Lock Operation

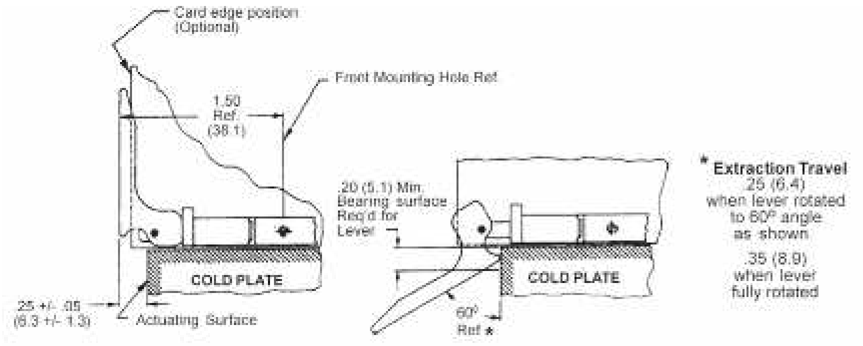

Figure 7-21 Card Lock Mechanism Detail

7.4.4.2 DRIVE CADDIES

ACOP hard drives are installed in exchangeable Drive Caddies. The primary purpose of the Drive Caddy is thermal management of the heat created by the hard drive operation. A secondary function is to provide easy handling of the drive by the crew – providing a handle and a blind mating mechanism.

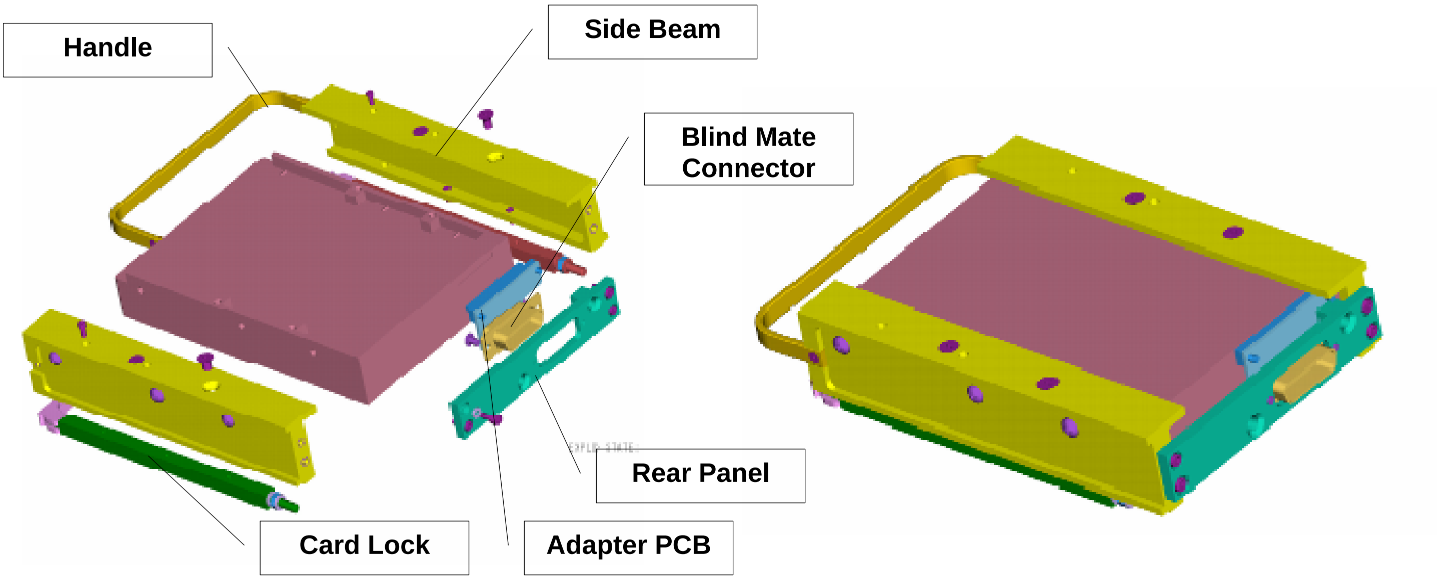

Figure 7-22 Drive Caddy Exploded and Assembled Views

The Drive Caddy is composed of two side beams, a handle, two card locks, small PCB adapter, and a rear panel. Two side beams are used for conducting heat from both sides of hard drives to the side heat sink fins of the CHASSIS.

The side beams are thermally integrated to the hard drive frame (the thermal reference point for the hard drive). Mounted on these beams are card locks which provide compression of the side beams to the Chassis thermal interfaces. The primary thermal path is via the side beam face opposite the card lock.

The PCB adapter provides the conversion from the hard drive connectors (not suitable for blind mating) to the blind mate connector (TBD). The rear panel with guide holes function as resistance support when blind mating.

There is floating connector with guide pins on Chassis side (see
Figure 7-23) which is free to move relative to the Drive Caddy connector. When the Drive Caddy is inserted to the Chassis card guide channels it the connectors are roughly aliened. As the Chassis mounted guide pins engage the Drive Caddy Rear Plate the floating connector on the chassis moves to provide proper alignment for full mating,

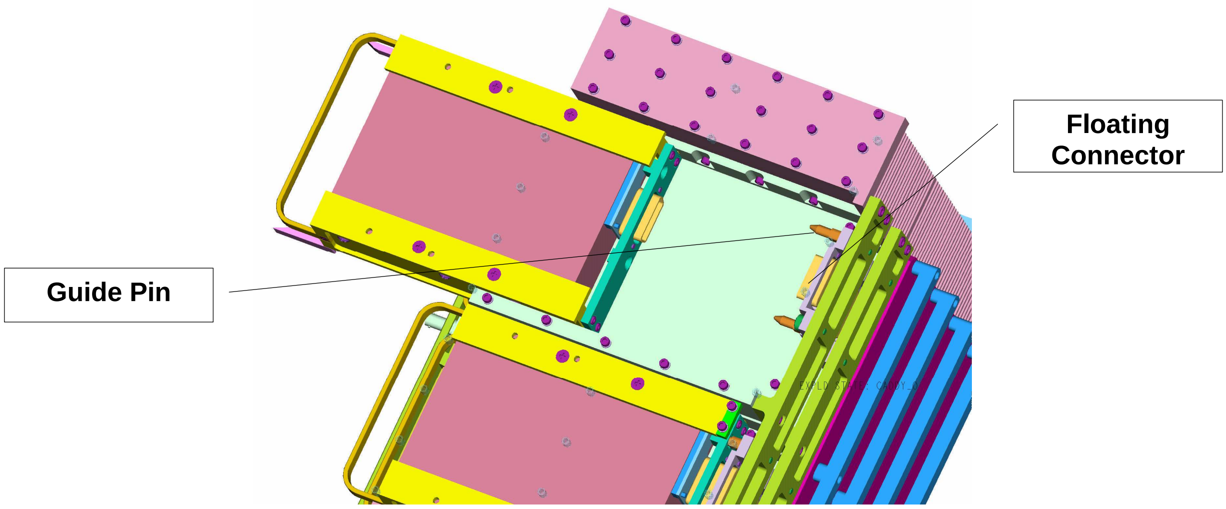

Figure 7-23 Chassis to Drive Caddy Mating Details

7.4.4.3 REAR CHASSIS AND BACK PLANE MECHANICS

Shown in Figure 7-24 are the PCB stiffener ribs supporting the CompactPCI back plane and the Caddy Mating Adapters which hold the Chassis side of the Drive Caddy blind mate connectors.

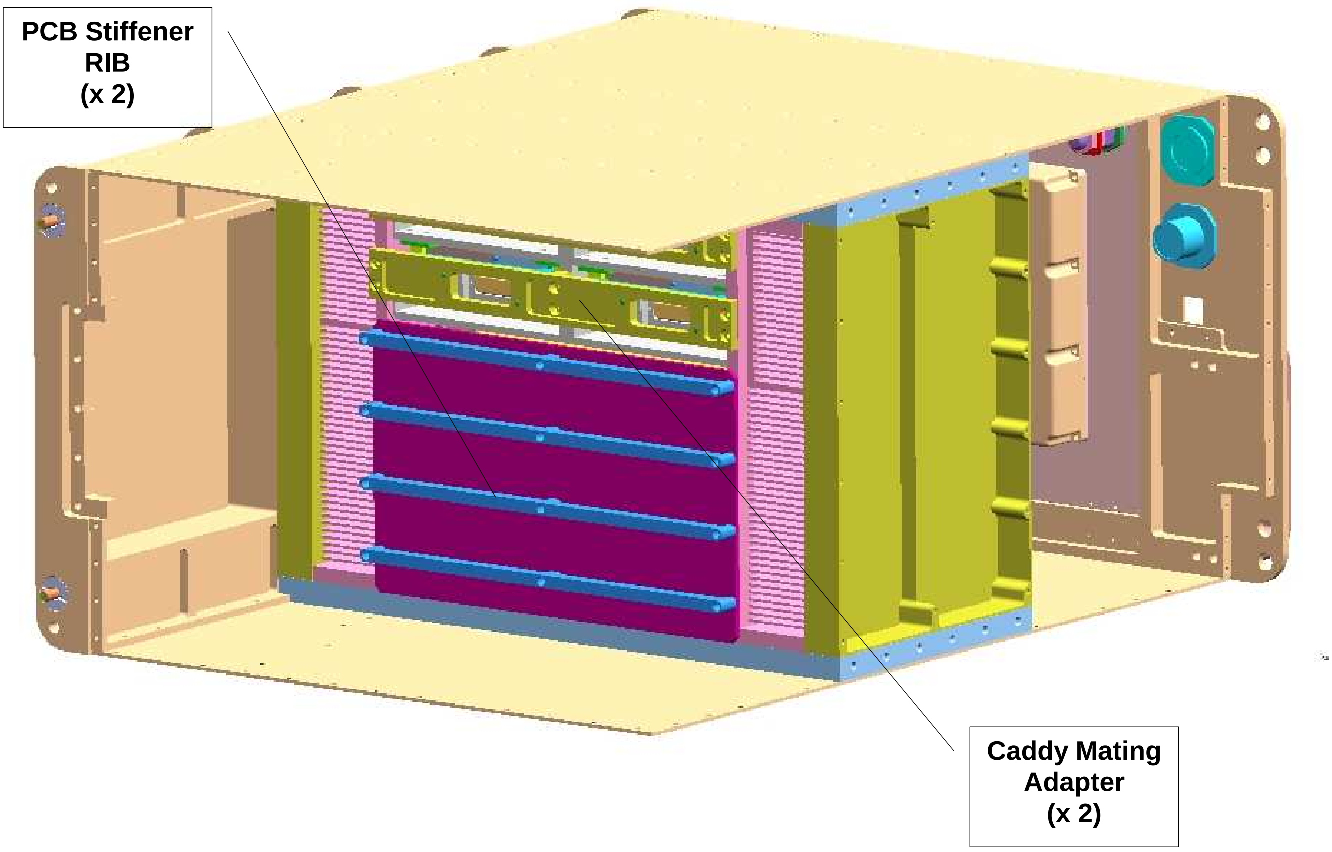

Figure 7-24 Rear Chassis Mechanics

7.4.4.4 CARD CAGE ASSEMBLY (CCA) DESIGN

The CCA design in the ACOP case is based on the “IEEE 1101.2 - Mechanical Core Specification for Conduction Cooled Eurocards” specification and the board layout is shown in Figure 7-25:

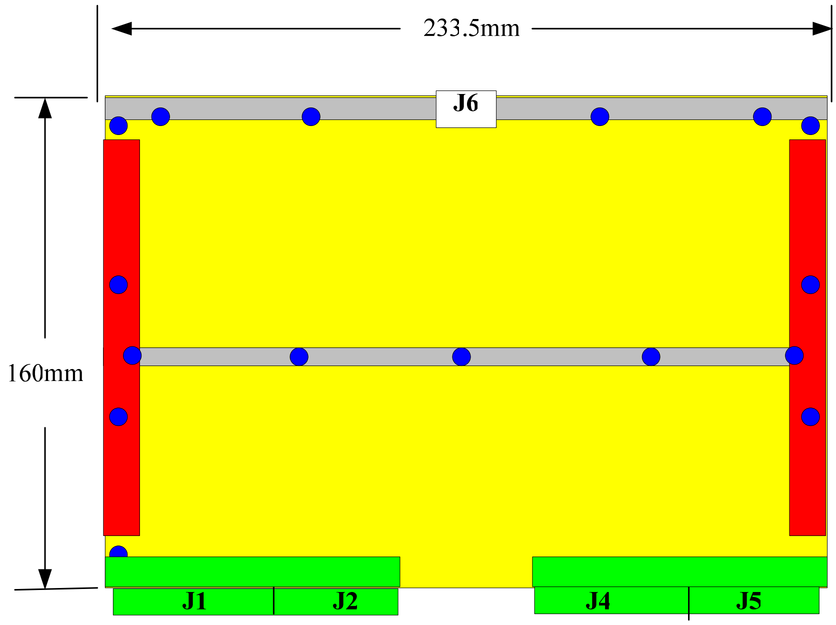

Figure 7-25 IEEE 1101.2 - Mechanical Core Specification for Conduction Cooled Eurocards

To allow ACOP to operate in the ISS, the boards design incorporates the following techniques:

- Buried thermal layers within the PCB and provide a good thermal conductivity from components to the board edge.
- Heat sink for high power components
- Stiffening ribs cross the board
- Expandable wedge lock on both sides
- Components location based on thermal analysis

Material and finished board dimensions of all CCAs are reported in the following table:

	ACOP-SBC	ACOP-T101	ACOP-T102	ACOP-T103	ACOP-T104	ACOP-BP	ACOP-PS	ACOP-VI
Material	Polymide (85N)	Polymide (85N)	Polymide (85N)	Polymide (85N)	Polymide (85N)	Polymide (85N)	Polymide (85N)	Polymide (85N)
Board thickness (mm)	1.6	1.6	1.6	1.6	1.6	3.0	1.6 (TBC)	1.6 (TBC)
Board dimensions (mm)	160x233.35	160x233.35	160x233.35	160x233.35	160x233.35	141.24x262.05	160x233.35	120.36x158

Table 7-1 ACOP PCB Specifications

7.4.4.5 POWER SUPPLY MECHANICAL CHARACTERISTICS

It's a CompactPCI 6U board size with conduction cooled feature (see Table 7-1 ACOP PCB Specifications). An aluminum heat sink is used as main board, the PCB is attached to the heat sink (see figure below). This design reduces the thermal resistance between components and crate wall.

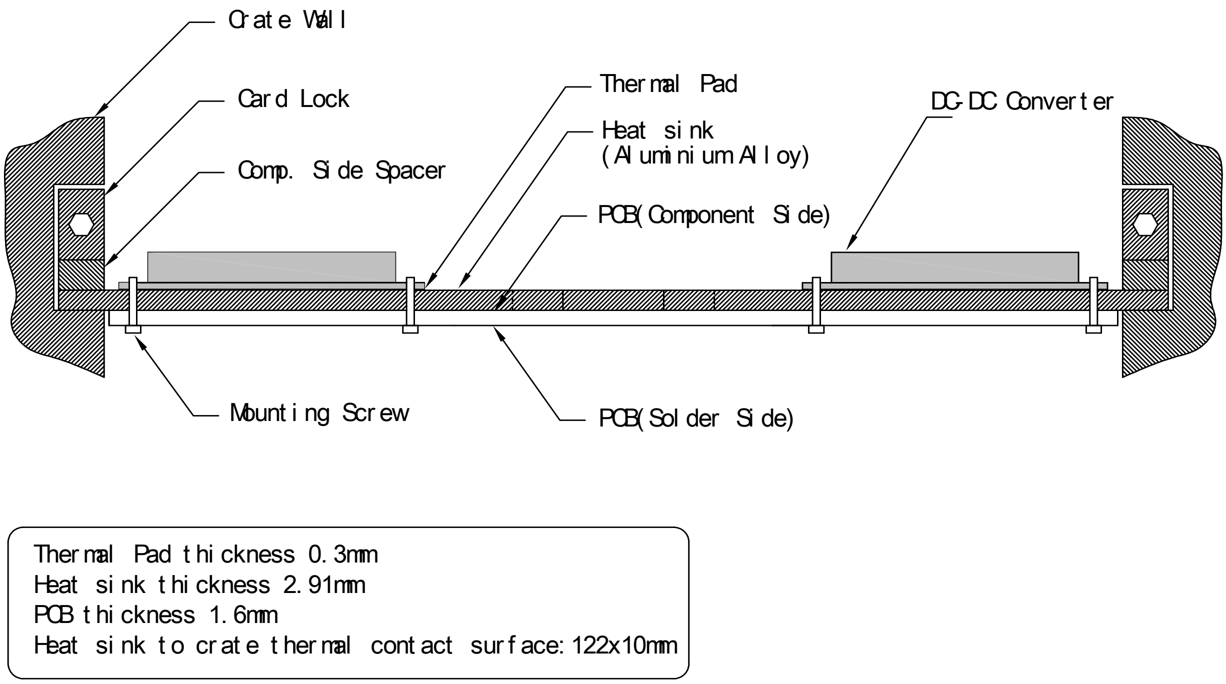

Figure 7-26 ACOP-PS Cross Section

7.5 PRINCIPAL AVIONICS COMPONENTS

Figure 7-27 shows the following principal avionics components:

- 5 Compact PCI cards
- 1 Power Supply
- 4 Hard Drives
- 1 LCD
- Connectors

There are four Drive Caddies installed in the upper part of the Chassis and five CompactPCI and with 6U power supply installed in the lower part of the Chassis.

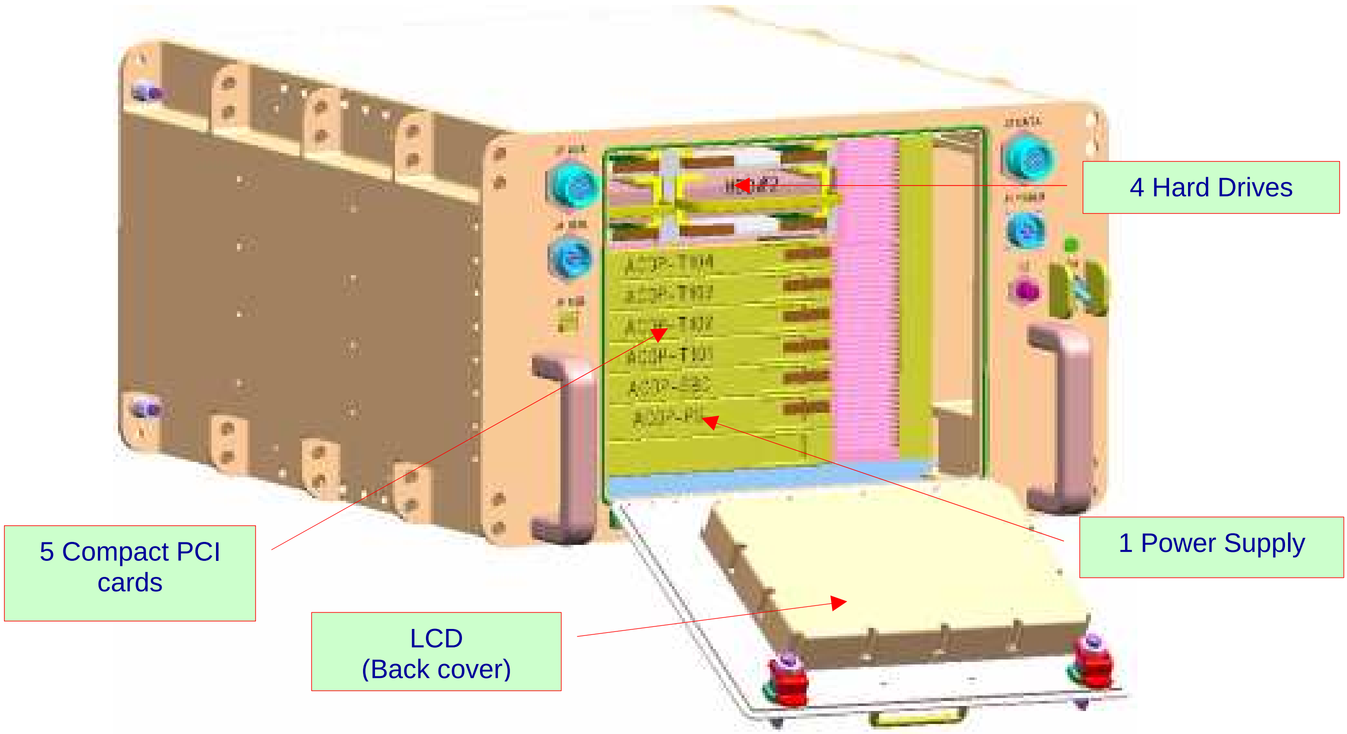

Figure 7-27 Principal Avionics Components

7.5.1 AVIONICS ON FRONT PANEL AND DOOR

All external connectors (Power, Data, HRDL, USB, and AUX), circuit breaker, power switch, and LED are mounted on the Front Panel. The LCD and push buttons are mounted on the Front Door.

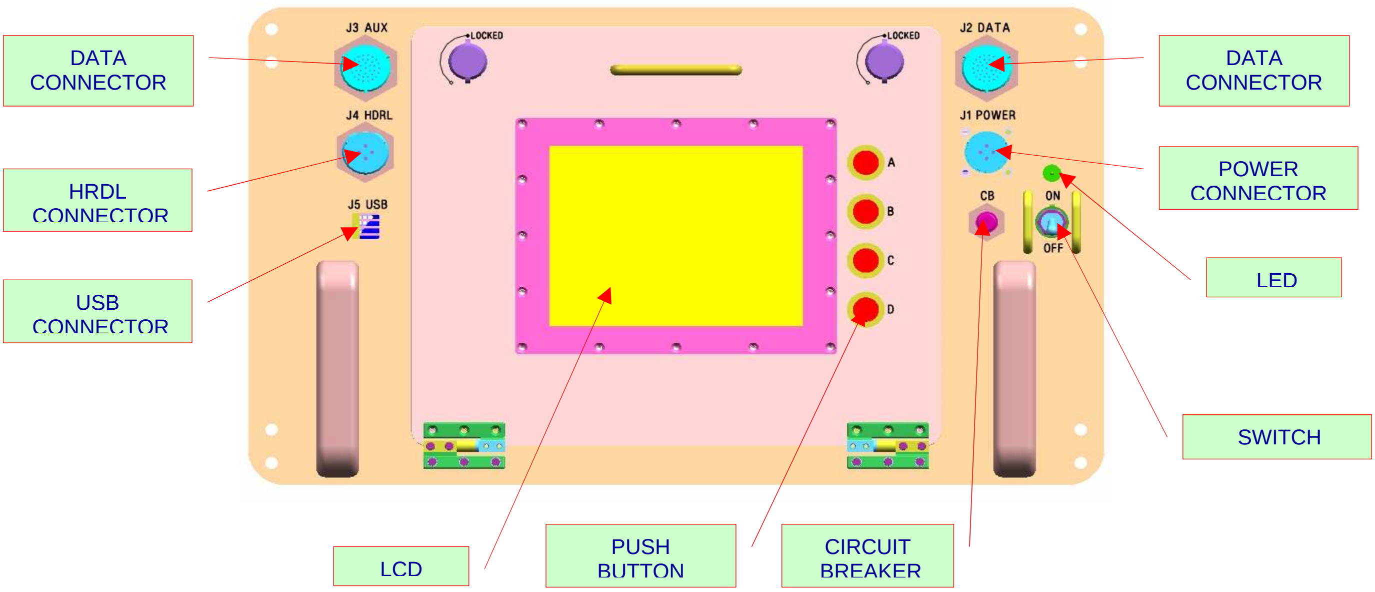

Figure 7-28 Layout on Front Panel and Front Door

7.5.2 CABLE AND HARNESS ROUTING

Several cables carrying signals to and from CompactPCI boards come from the board front panels and go ether to the front panel area or to the rear of the Chassis. There are passages through the side baffles and bottom plate to accommodate cables.

The power and sensor cables of the Fan Assembly come out from the Back Plane and go directly to the Fan Assembly blind mate.

This section shows only a preliminary layout of the cabling. Detailed path design and clamping locations will be defined at final design time.

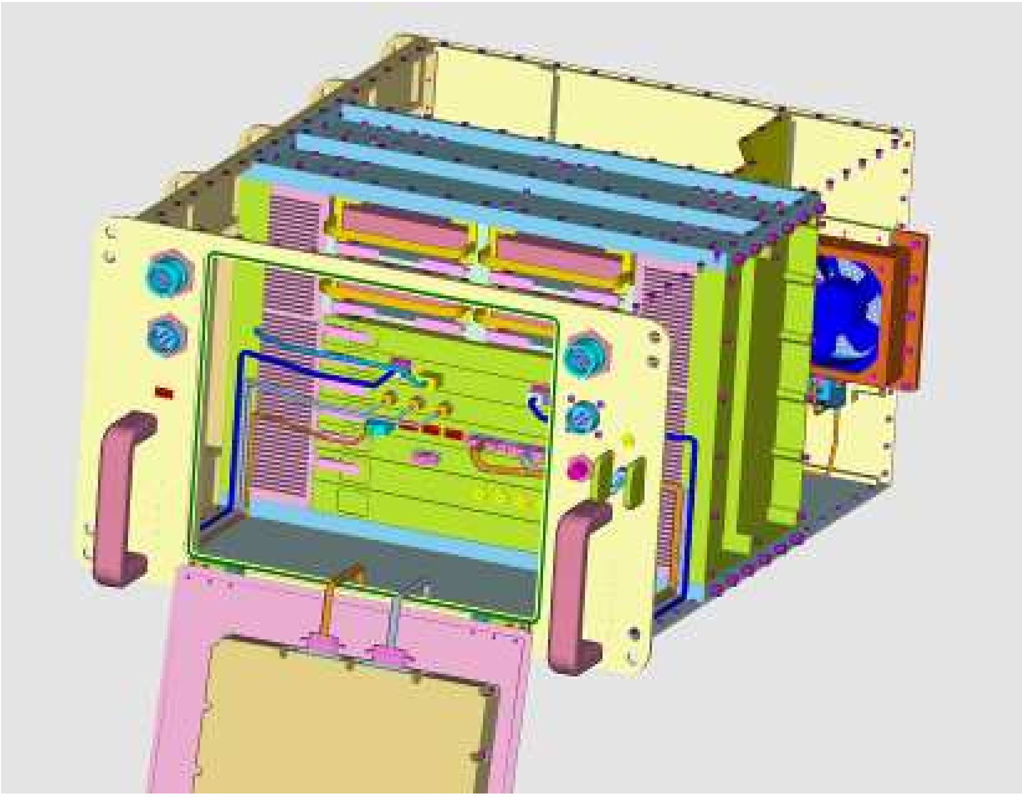

Figure 7-29 Layout of Cabling Front View

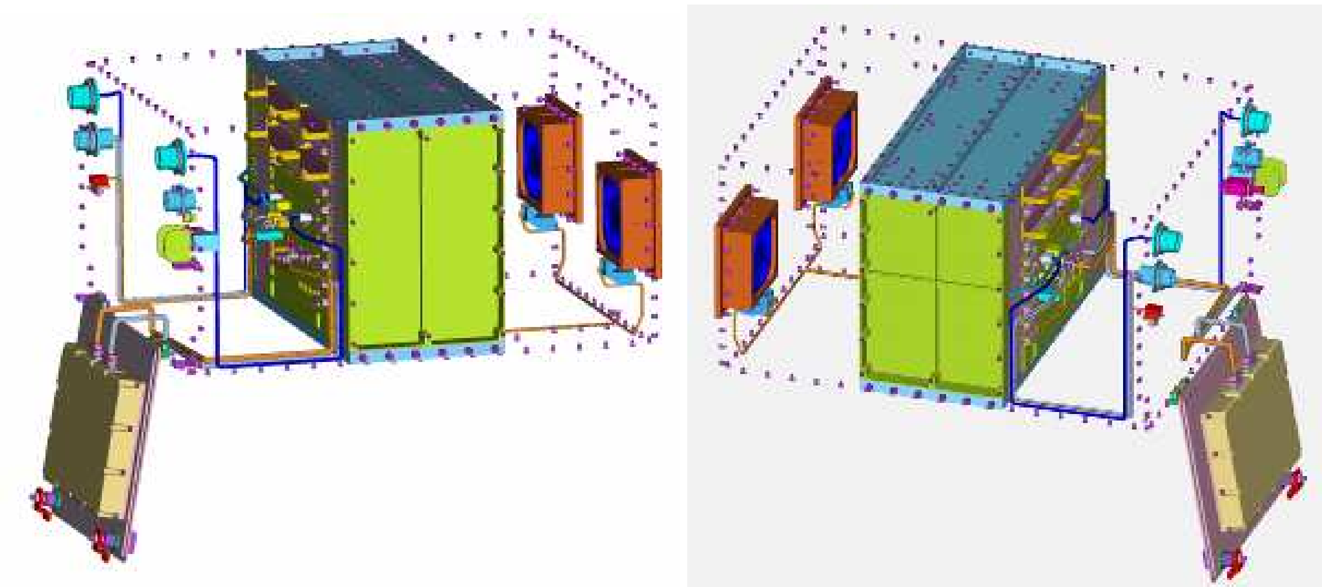

Figure 7-30 Layout of Cabling – Transparent Side Views

7.5.3 THERMAL DESIGN

Heat dissipation of the hard disk drives, CompactPCI boards, and the power supply will be conducted to the heat sink fin walls by conduction. The rear access cooling airflow (via Avionics Air Assembly) will be drawn in by the inlet fan and through 1) the fins and 2) gap between Drive Caddy and the Caddy Plates to remove the heat by forced convection. Warm air will enter the outlet side of the rear of ACOP and will be exhausted by the outlet fan.[8]

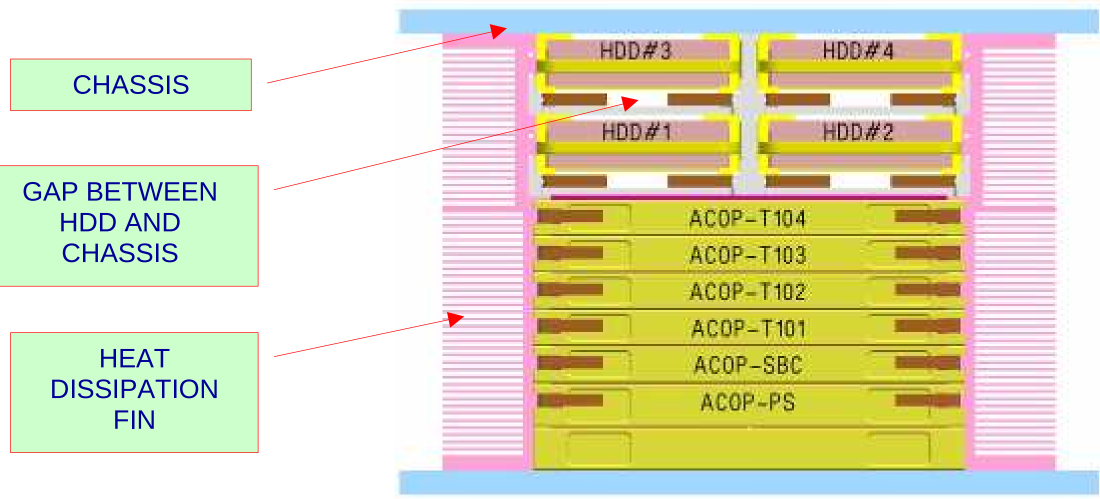

Figure 7-31 Thermal design (front view)

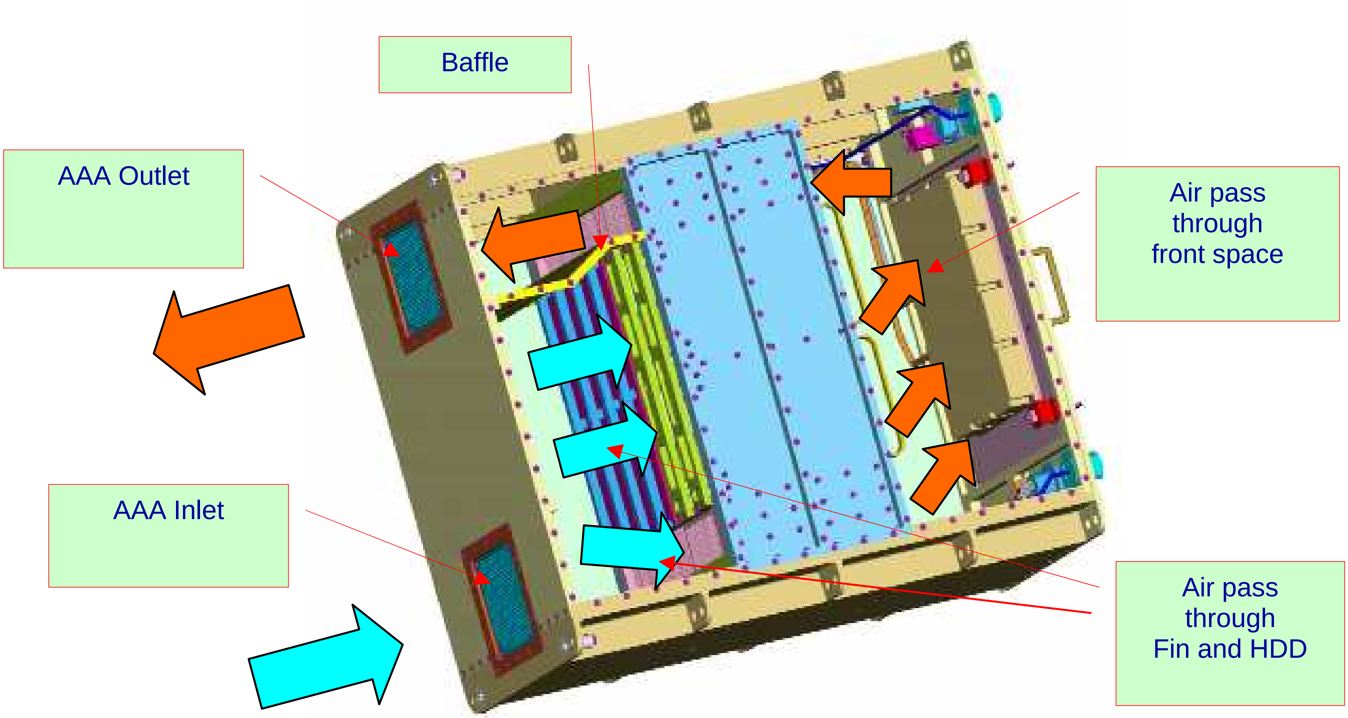

Figure 7-32 Cooling airflow (top view)

[8] The inlet and outlet fans are independently managed by the software. Either fan moves enough cooling air to provide nominal operations.

7.6 MECHANICAL DESIGN DETAILS

7.6.1 ELEMENTARY INFORMATION OF MECHANICAL PARTS

Item	Main Dimension (mm)	Quantity	Mass (g)	Material	Fabrication Method
Front Panel Plate	460.3 x 273.2 x 13	1	1009	7075 T7351	Machine milling
Door Plate	265 x 239.5 x 21	1	1476	7075 T7351	Machine milling
Right & Left Side Plates	535 x 273.2 x 40.3	2	2 x 2320	7075 T7351	Machine milling
Top & Bottom Plates	387.8 x 527.5 x 2	2	2 x 1132	7075 T7351	Machine milling
Back Plate	388 x 273.2 x 16.8	1	1002	7075 T7351	Machine milling
Fan Frame	120 x 120 x 42	2	2 x 250	7075 T7351	Machine milling
Chassis Top & Bottom	388 x 175.6 x 13.6	2	2 x 636	6061T6	Machine milling
Caddy Plate Top	245.4 x 45 x 167	1	676	6061T6	Machine milling
Caddy Plate Bottom	245.4 x 45 x 167	1	646	6061T6	Machine milling
Right & Left Fin	60.3 x 242 x 175.6	2	2 x 3042	6061T6	Machine milling
Baffle	162 x 35 x 269.2	1	277	6061T6	Machine milling
Right & Left Baffle	241.8 x 175.6 x 23.8	2	2 x 277	6061T6	Machine milling
Drive Caddy	193.4 x 112.7 x 40.2	4	4 x 220	6061T6	Machine milling

Table 7-2 Mechanical Parts List

7.6.2 MATERIALS

Mechanical parts of the Locker are fabricated with alloy aluminum 7075T7351. Mechanical parts of the Chassis and Caddy are fabricated with alloy aluminum 6061T6.

All the screws and bolts are stainless steel A286 (see attached part list).

7.6.3 MACHINING AND ASSEMBLY

Both Locker and Chassis will be assembled by several parts which are mainly produced by machine milling. Assemblies are integrated by stainless fasteners according to MIL-SPEC. Materials and processes will meet the requirements in section 13 of the IDD.

7.6.4 SURFACE TREATMENTS

Surface treatments used:

- Clear anodizing class 1 according to Spec.MIL-A-8625 TYPE II CLASS 1
- Alodine 1200 class 3 according to Spec.MIL-C-5541 CLASS 3 (for mating surfaces which must guarantee low electrical resistivity).
- Off-white semi-gloss polyurethane topcoat for Front Panel and Door. (Primer PAC33 4355/3600 Paint PU66 5461/1311)

7.7 MECHANICAL INTERFACES

7.7.1 STRUCTURE MOUNTED INTERFACE

ACOP is mounted to the EXPRESS rack back plate by four TYPE B Captive Bolts.

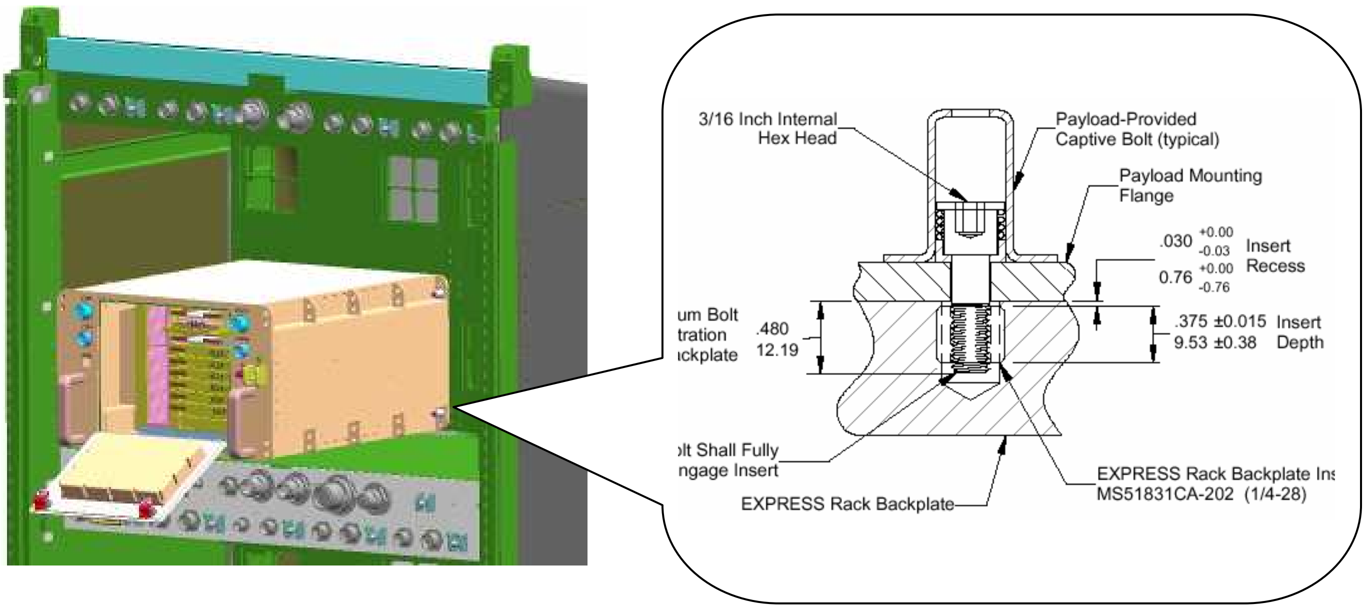

Figure 7-33 Structure Interface

7.7.2 AIRFLOW INTERFACE

Cooling airflow via Avionics Air Assembly (AAA) will blow in and out by fans and through the ports on back plate of the Rack.

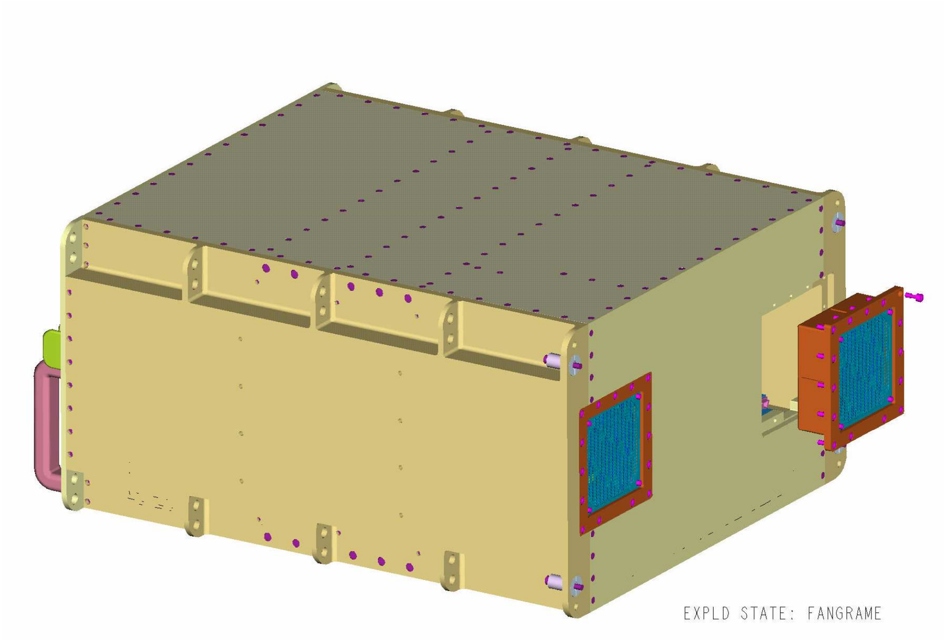

Figure 7-34 Replacing Fan module

7.7.3 REPLACING SCREEN

The crew should replace the filter of fan when air filter is dirty.

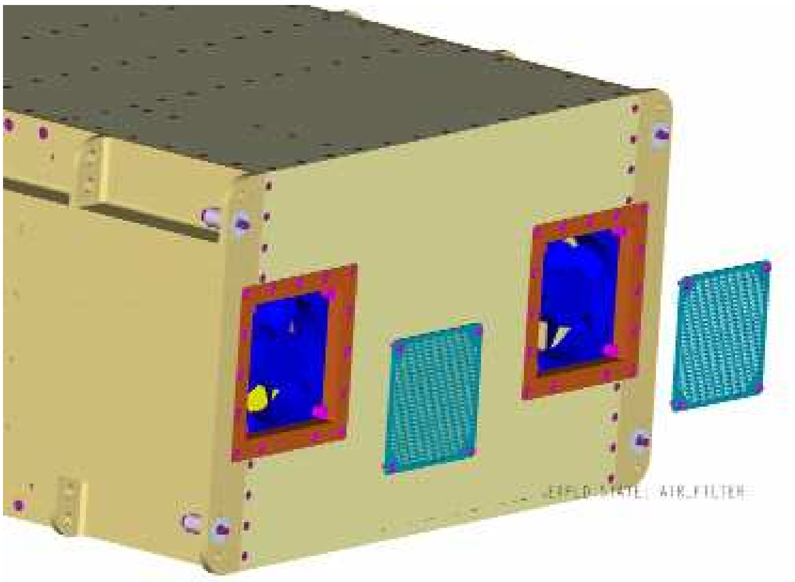

Figure 7-35 Replacing screen

7.7.4 TOOLS

ACOP is operated and maintained using standard GFE tools

7.8 MASS BUDGET

Item	Mass [Kg]	Contingency [%]	Mass with contingency [Kg]
LOCKER	12.716	5%	13.352
CHASSIS	9.096	5%	9.55
ACOP-SBC	0.4	5%	0.42
ACOP-T101	0.35	5%	0.368
ACOP-T102	0.35	5%	0.368
ACOP-T103	0.35	5%	0.368
ACOP-T104	0.35	5%	0.368
ACOP-BP	0.22	10%	0.242
ACOP-PS	1.00	10%	1.1
INLET FAN	0.17	5%	0.179
OUTLET FAN	0.17	5%	0.179
ACOP-LCD	0.187	5%	0.196
ACOP-VI	0.100	5%	0.105
4 x HDD	2.328	5%	2.444
4 x CADDY	1.00	5%	1.05
CONNECTORS, CABLE	2.0	5%	2.1
Total	**30.787**		32.387

Table 7-3 Mass Budget

8. CREW TRAINING SYSTEMS

The ACOP program will deliver a suitable training model. This section notes the training requirements for ACOP.

8.1 APPLICABLE DOCUMENTS

The following documents where used in developing this section.

Number	Rev	Date	Title
SSP 57066	Initial	28-Oct-03	Standard Payload Integration Agreement for EXPRESS/WORF Rack Payloads
SSP 58026-01	B	Sep-03	Generic Payload Simulator Requirements Document, Volume I

Table 8-1 Applicable Training Documents

8.2 MAJOR REQUIREMENTS FROM SSP57066 (SPIA)

A. The PD shall participate in the Training Strategy Team (TST) process for the purpose of defining crew and GSP training and simulator requirements. *(TST process is defined by SSP58309.)*

B. To support payload training, the PD shall develop and deliver to JSC a payload simulator that will support crew training on nominal, maintenance, safety-related and limited malfunction operations *(The delivery is a Payload Training Unit (PTU) defined by SSP 58026-01).*

C. Training simulators for all but simple or single-increment payloads will provide high fidelity crew interfaces and will be integrated into the Space Station Training Facility (SSTF)/Payload Training Capability (PTC).

D. The PD shall support the development of training plans, procedures, courseware, or other materials for all training related to their payload.

8.3 MAJOR REQUIREMENTS FROM SSP58026-01

A. The PTU (or PTUs) shall be capable of supporting training in the following nine categories: Payload Science/Operations, Payload Transport, Payload Transfer, Payload Proficiency, Payload Refresher, Payload Complement, Payload-Only Simulation, Integrated Payload-Only Simulations, and Joint Multi-Segment.

B. The PD shall deliver a PTU Trainer Development Specification (TDS).

C. The PD shall deliver a PTU Trainer Development Specification (TDS). This specification shall include, as a minimum, the following information:

1 Overall architecture
2 Components list
3 Interfaces to SSTF/PTC resources
4 Hardware design
5 Software design, including:
  (1) Interfaces to SSTF cores system models
  (2) Operating modes
  (3) Malfunction capabilities
  (4) IOS display parameters
6 Crew interface definition
7 Lifetime requirements
8 Physical configuration requirements

9 Thermal environment requirements
10 Handling and transportation requirements
11 Documentation requirements
12 Maintenance requirements
13 Safety requirements

This document shall be submitted for review within a reasonable time at or near the PDR and CDR for the payload flight unit.

D. The PTU shall be provided as a self-contained MDL or ISIS drawer mockup with flight-like front panel (or other) interfaces to the EXPRESS Rack provided. The PTU shall not require external control or support equipment to operate; all such equipment shall be contained within the rack volume.

E. The PTU shall provide the necessary flight-like interfaces to the RIC model to support the crew's interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command and monitoring by the GSP.

F. The PTU shall simulate the communications protocols with the RIC model required to support the flight-like interfaces.

G. The PTU shall output a simulated health and status data stream through the RIC data-link (RS-422 or Ethernet)

H. The PTU shall be built to operate with the power available from the EXPRESS Rack Simulator.

I. The PTU shall respond to the switched 28Vdc supply for power on/off status, even if the PTU does not otherwise use this power to operate.

J. Payload Simulation Network (PSimNet) … individual EXPRESS payload PTUs are required to pass simulated systems loading information to the RIC as specified in the EXPRESS Rack Simulator IDD.

K. The PD shall provide the interface cables between the EXPRESS Rack Simulator and the PTU *(Flight-like cables (total fidelity))*

L. Prior to delivering the PTU to the SSTF/PTC, the PD shall host a representative to conduct a Simulator Pre-Shipment Test *(With ScS-E)*.